

BC95 Hardware Design

NB-IoT Module Series

Rev. BC95_Hardware_Design_V1.3

Date: 2017-06-15



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

Quectel Wireless Solutions Co., Ltd.

Office 501, Building 13, No.99, Tianzhou Road, Shanghai, China, 200233

Tel: +86 21 5108 6236

Email: info@quectel.com

Or our local office. For more information, please visit:

<http://www.quectel.com/support/salesupport.aspx>

For technical support, or to report documentation errors, please visit:

<http://www.quectel.com/support/techsupport.aspx>

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.

COPYRIGHT

THE INFORMATION CONTAINED HERE IS PROPRIETARY TECHNICAL INFORMATION OF QUECTEL CO., LTD. TRANSMITTING, REPRODUCTION, DISSEMINATION AND EDITING OF THIS DOCUMENT AS WELL AS UTILIZATION OF THE CONTENT ARE FORBIDDEN WITHOUT PERMISSION. OFFENDERS WILL BE HELD LIABLE FOR PAYMENT OF DAMAGES. ALL RIGHTS ARE RESERVED IN THE EVENT OF A PATENT GRANT OR REGISTRATION OF A UTILITY MODEL OR DESIGN.

Copyright © Quectel Wireless Solutions Co., Ltd. 2017. All rights reserved.

About the Document

History

Revision	Date	Author	Description
1.0	2016-11-30	Bryant CHEN/ Mark ZHANG	Initial
1.1	2017-01-24	Bryant CHEN/ Mark ZHANG	<ol style="list-style-type: none"> 1. Modified module's current consumption in PSM. 2. Changed the name of BC95 variants from BC95-CM/BC95-SL/BC95-VF to BC95-B8/BC95-B5/BC95-B20. 3. Enabled main port to upgrade firmware. 4. Updated current consumption in Table 23.
1.2	2017-03-15	Bryant CHEN/ Mark ZHANG	<ol style="list-style-type: none"> 1. Deleted information of SWD interface. 2. Modified typical supply voltage of the module. 3. Added the power saving information. 4. Modified the UART level match circuit. 5. Updated bottom dimensions of the module.
1.3	2017-06-15	Ewent LU/ Mark ZHANG	<ol style="list-style-type: none"> 1. Added Band 28 in Table 1. 2. Updated data transmission feature and module weight in Table 2. 3. Updated the description of operating modes in Chapter 3.4. 4. Updated the description of resetting the module in Chapter 3.6.3. 5. Updated the description of power saving mode in Chapter 3.7. 6. Added information about electrostatic discharge characteristics in Table 23. 7. Updated the description of installing the antenna with RF connector in Chapter 4.7.

Contents

About the Document.....	2
Contents.....	3
Table Index.....	5
Figure Index.....	6
1 Introduction.....	7
1.1. Safety Information.....	8
2 Product Concept.....	9
2.1. General Description.....	9
2.2. Key Features.....	10
2.3. Functional Diagram.....	11
2.4. Evaluation Board.....	12
3 Application Functions.....	13
3.1. General Description.....	13
3.2. Pin Assignment.....	14
3.3. Pin Description.....	15
3.4. Operating Modes.....	18
3.5. Power Supply.....	18
3.5.1. Power Supply Pins.....	18
3.5.2. Reference Design for Power Supply.....	19
3.6. Power on and down Scenarios.....	19
3.6.1. Power on.....	19
3.6.2. Power down.....	20
3.6.3. Reset the Module.....	20
3.7. Power Saving.....	21
3.8. UART Interfaces.....	22
3.8.1. Main Port.....	23
3.8.2. Debug Port.....	24
3.8.3. UART Application.....	25
3.9. USIM Card Interface.....	26
3.9.1. USIM Card Application.....	26
3.10. ADC Interface*.....	28
3.11. Behaviors of RI*.....	28
3.12. Network Status Indication*.....	29
4 Antenna Interface.....	31
4.1. RF Antenna Reference Design.....	31
4.2. Reference Design of RF Layout.....	32
4.3. RF Output Power.....	34
4.4. RF Receiving Sensitivity.....	34
4.5. Operating Frequencies.....	35

4.6.	Antenna Requirement	35
4.7.	Install the Antenna with RF Connector	36
5	Electrical, Reliability and Radio Characteristics	38
5.1.	Absolute Maximum Ratings.....	38
5.2.	Operating Temperature	38
5.3.	Current Consumption	39
5.4.	Electrostatic Discharge.....	40
6	Mechanical Dimensions	41
6.1.	Mechanical Dimensions of the Module	41
6.2.	Recommended Footprint.....	43
6.3.	Design Effect Drawings of the Module	44
7	Storage, Manufacturing and Packaging	45
7.1.	Storage	45
7.2.	Manufacturing and Soldering	46
7.3.	Packaging.....	47
7.3.1.	Tape and Reel Packaging	47
8	Appendix A References.....	49

Quectel
Confidential

Table Index

TABLE 1: FREQUENCY BANDS OF BC95 SERIES MODULE.....	9
TABLE 2: BC95 KEY FEATURES	10
TABLE 3: I/O PARAMETERS DEFINITION.....	15
TABLE 4: PIN DESCRIPTION.....	15
TABLE 5: OVERVIEW OF OPERATING MODES.....	18
TABLE 6: VBAT AND GND PINS.....	18
TABLE 7: RESET CHARACTERISTICS	21
TABLE 8: PIN DEFINITION OF THE UART INTERFACES	23
TABLE 9: LOGIC LEVELS OF THE UART INTERFACES	23
TABLE 10: PIN DEFINITION OF THE USIM CARD INTERFACE	26
TABLE 11: PIN DEFINITION OF THE ADC.....	28
TABLE 12: BEHAVIORS OF RI	28
TABLE 13: WORKING STATE OF THE NETLIGHT	29
TABLE 14: PIN DEFINITION OF THE RF ANTENNA INTERFACE.....	31
TABLE 15: RF OUTPUT POWER (UPLINK QPSK AND BPSK MODULATION).....	34
TABLE 16: RF RECEIVING SENSITIVITY (THROUGHPUT ≥ 95%).....	34
TABLE 17: OPERATING FREQUENCIES	35
TABLE 18: ANTENNA CABLE REQUIREMENT	35
TABLE 19: ANTENNA REQUIREMENTS.....	35
TABLE 20: ABSOLUTE MAXIMUM RATINGS	38
TABLE 21: OPERATING TEMPERATURE.....	38
TABLE 22: CURRENT CONSUMPTION.....	39
TABLE 23: ELECTROSTATIC DISCHARGE CHARACTERISTICS	40
TABLE 24: RELATED DOCUMENTS.....	49
TABLE 25: TERMS AND ABBREVIATIONS.....	49

Figure Index

FIGURE 1: FUNCTIONAL DIAGRAM	11
FIGURE 2: PIN ASSIGNMENT	14
FIGURE 3: REFERENCE CIRCUIT FOR THE VBAT INPUT	19
FIGURE 4: TURN-ON TIMING	20
FIGURE 5: TURN-OFF TIMING	20
FIGURE 6: REFERENCE CIRCUIT OF RESET BY USING DRIVING CIRCUIT	21
FIGURE 7: REFERENCE CIRCUIT OF RESET BY USING BUTTON	21
FIGURE 8: DIAGRAM FOR POWER CONSUMPTION.....	22
FIGURE 9: REFERENCE DESIGN FOR MAIN PORT	24
FIGURE 10: REFERENCE DESIGN FOR DEBUG PORT	24
FIGURE 11: LEVEL MATCH DESIGN FOR 3.3V SYSTEM.....	25
FIGURE 12: SKETCH MAP FOR RS-232 INTERFACE MATCH.....	26
FIGURE 13: REFERENCE CIRCUIT FOR USIM INTERFACE WITH 6-PIN USIM CARD CONNECTOR	27
FIGURE 14: BEHAVIORS OF RI WHEN A URC OR SMS IS RECEIVED	29
FIGURE 15: REFERENCE DESIGN FOR NETLIGHT	30
FIGURE 16: REFERENCE DESIGN FOR RF	31
FIGURE 17: MICROSTRIP LINE DESIGN ON A 2-LAYER PCB.....	32
FIGURE 18: COPLANAR WAVEGUIDE LINE DESIGN ON A 2-LAYER PCB.....	32
FIGURE 19: COPLANAR WAVEGUIDE LINE DESIGN ON A 4-LAYER PCB (LAYER 3 AS REFERENCE GROUND).....	33
FIGURE 20: COPLANAR WAVEGUIDE LINE DESIGN ON A 4-LAYER PCB (LAYER 4 AS REFERENCE GROUND).....	33
FIGURE 21: DIMENSIONS OF THE UF.L-R-SMT CONNECTOR (UNIT: MM)	36
FIGURE 22: MECHANICALS OF UF.L-LP CONNECTORS	36
FIGURE 23: SPACE FACTOR OF MATED CONNECTOR (UNIT: MM)	37
FIGURE 24: MODULE TOP AND SIDE DIMENSIONS.....	41
FIGURE 25: MODULE BOTTOM DIMENSIONS (BOTTOM VIEW)	42
FIGURE 26: RECOMMENDED FOOTPRINT (TOP VIEW)	43
FIGURE 27: TOP VIEW OF THE MODULE	44
FIGURE 28: BOTTOM VIEW OF THE MODULE	44
FIGURE 29: REFLOW SOLDERING THERMAL PROFILE.....	46
FIGURE 30: TAPE DIMENSIONS	47
FIGURE 31: REEL DIMENSIONS	48

1 Introduction

This document defines the BC95 module and describes its air interface and hardware interface which are connected with customers' applications.

This document can help customers to quickly understand module interface specifications, electrical and mechanical details. Associated with application note and user guide, customers can use BC95 module to design and set up mobile applications easily.

Quectel
Confidential

1.1. Safety Information

The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating BC95 module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for the customers' failure to comply with these precautions.



Full attention must be given 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. You must comply with laws and regulations restricting the use of wireless devices while driving.



Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden, so as to prevent interference with communication systems. Consult the airline staff about the use of wireless devices on boarding the aircraft, if your device offers an Airplane Mode which must be enabled prior to boarding an aircraft.



Switch off your wireless device when in hospitals, clinics or other health care facilities. These requests are designed to prevent possible interference with sensitive medical equipment.



Cellular terminals or mobiles operating over radio frequency signal and cellular network cannot be guaranteed to connect in all conditions, for example no mobile fee or with an invalid (U)SIM card. While you are in this condition and need emergent help, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength.



Your cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency energy. 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 your 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.

2 Product Concept

2.1. General Description

BC95 is a series of NB-IoT module which contains four variants: BC95-B8, BC95-B5, BC95-B20 and BC95-B28*. It is designed to communicate with mobile network operators' infrastructure equipment through the NB-IoT radio protocol (3GPP Rel-13). The following table shows the frequency bands of BC95 series module.

Table 1: Frequency Bands of BC95 Series Module

Mode	BC95-B8	BC95-B5	BC95-B20	BC95-B28*
H-FDD	Band 8	Band 5	Band 20	Band 28

BC95 is an SMD type module with LCC package, with an ultra-compact profile of 19.9mm × 23.6mm × 2.2mm, which can be easily embedded into applications. It provides hardware interfaces such as ADC and UART interfaces, and can meet almost all the requirements for IoT applications, such as smart metering, bike sharing, smart parking, smart city, security and asset tracking, home appliances, agricultural and environmental monitoring, etc.

Designed with power saving technique, the BC95 consumes an ultra-low current of 5uA in PSM (Power Saving Mode).

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

NOTE

“*” means under development.

2.2. Key Features

The following table describes the detailed features of BC95 module.

Table 2: BC95 Key Features

Feature	Details
Power Supply	<ul style="list-style-type: none"> ● Supply voltage: 3.1V ~ 4.2V ● Typical supply voltage: 3.6V
Power Saving Mode	<ul style="list-style-type: none"> ● Maximum power consumption in PSM: 5uA
Transmitting Power	<ul style="list-style-type: none"> ● 23dBm±2dB
Temperature Range	<ul style="list-style-type: none"> ● Operation temperature range: -30°C ~ +75°C¹⁾ ● Extended temperature range: -40°C ~ +85°C²⁾
USIM Interface	<ul style="list-style-type: none"> ● Only support USIM card: 3.0V
UART Interfaces	<p>Main port:</p> <ul style="list-style-type: none"> ● Used for AT command communication and data transmission, and the baud rate is 9600bps ● Main port can also be used for firmware upgrading, and the baud rate is 115200bps <p>Debug port:</p> <ul style="list-style-type: none"> ● Debug port is used for debugging ● Only support 921600bps baud rate
Internet Protocol Features	<ul style="list-style-type: none"> ● Support IPV4/IPV6*/UDP/CoAP
SMS*	<ul style="list-style-type: none"> ● Text and PDU mode ● Point to point MO and MT
Data Transmission Feature	<ul style="list-style-type: none"> ● Single tone with 15kHz subcarrier: 24kbps (DL), 15.625kbps (UL)
AT Commands	<ul style="list-style-type: none"> ● Compliant with 3GPP TS 27.005, 27.007 and Quectel enhanced AT commands
Physical Characteristics	<ul style="list-style-type: none"> ● Size: (19.9±0.15)mm × (23.6±0.15)mm × (2.2±0.2mm) ● Weight: 1.8g±0.2g
Firmware Upgrade	<ul style="list-style-type: none"> ● Firmware upgrade via main port or DFOTA*
Antenna Interface	<ul style="list-style-type: none"> ● Connected to antenna pad with 50 Ohm impedance control
RoHS	<ul style="list-style-type: none"> ● All hardware components are fully compliant with EU RoHS directive

NOTES

1. ¹⁾ Within operation temperature range, the module is 3GPP compliant.
2. ²⁾ Within extended temperature range, the module remains the ability to establish and maintain an SMS*, data transmission, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.
3. "*" means under development.

2.3. Functional Diagram

The following figure shows a block diagram of BC95 and illustrates the major functional parts.

- Radio frequency
- Power management
- Peripheral interfaces

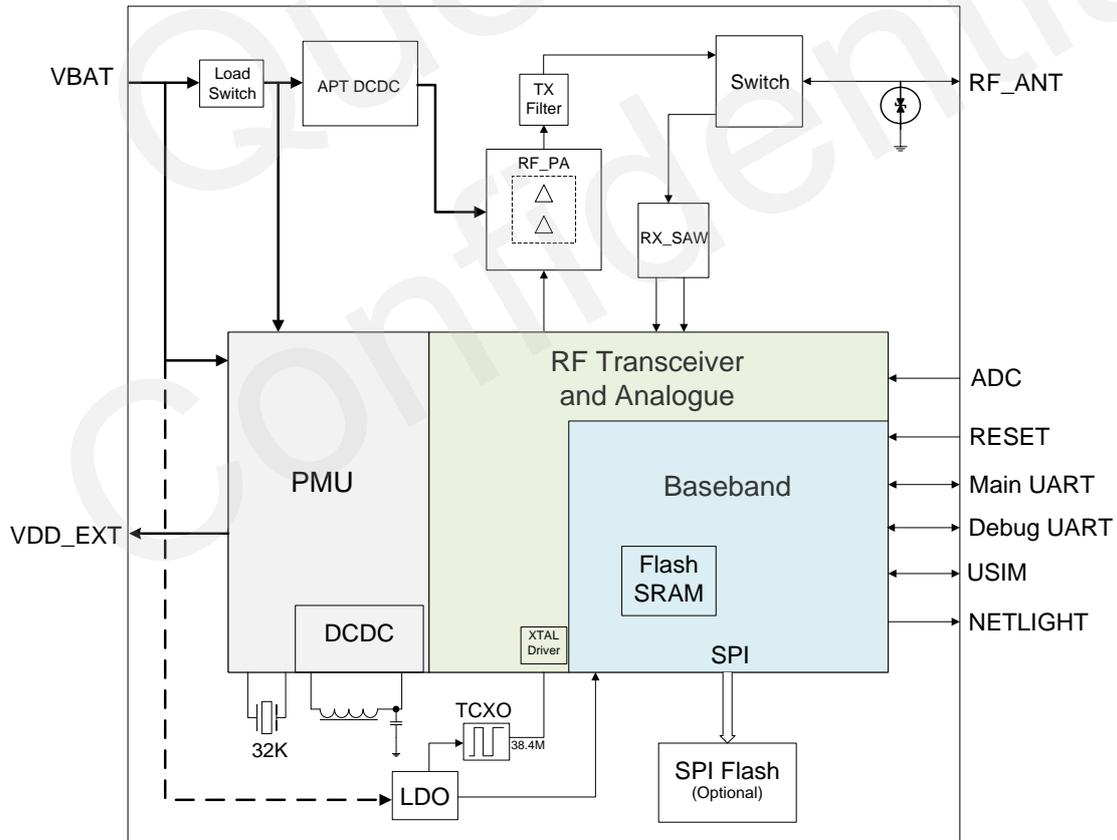


Figure 1: Functional Diagram

2.4. Evaluation Board

In order to help customers to develop applications with BC95, Quectel supplies the evaluation board (EVB), RS-232 to USB cable, power adapter, antenna and other peripherals to control or test the module.

Quectel
Confidential

3 Application Functions

3.1. General Description

BC95 is equipped with 54-pin 1.1mm pitch SMT pads plus 40-pin ground/reserved pads. The following chapters provide detailed descriptions of these pins:

- Power supply
- UART interfaces
- USIM card interface
- ADC interface*
- Network status indication*
- RF interface

Quectel
Confidential

3.2. Pin Assignment

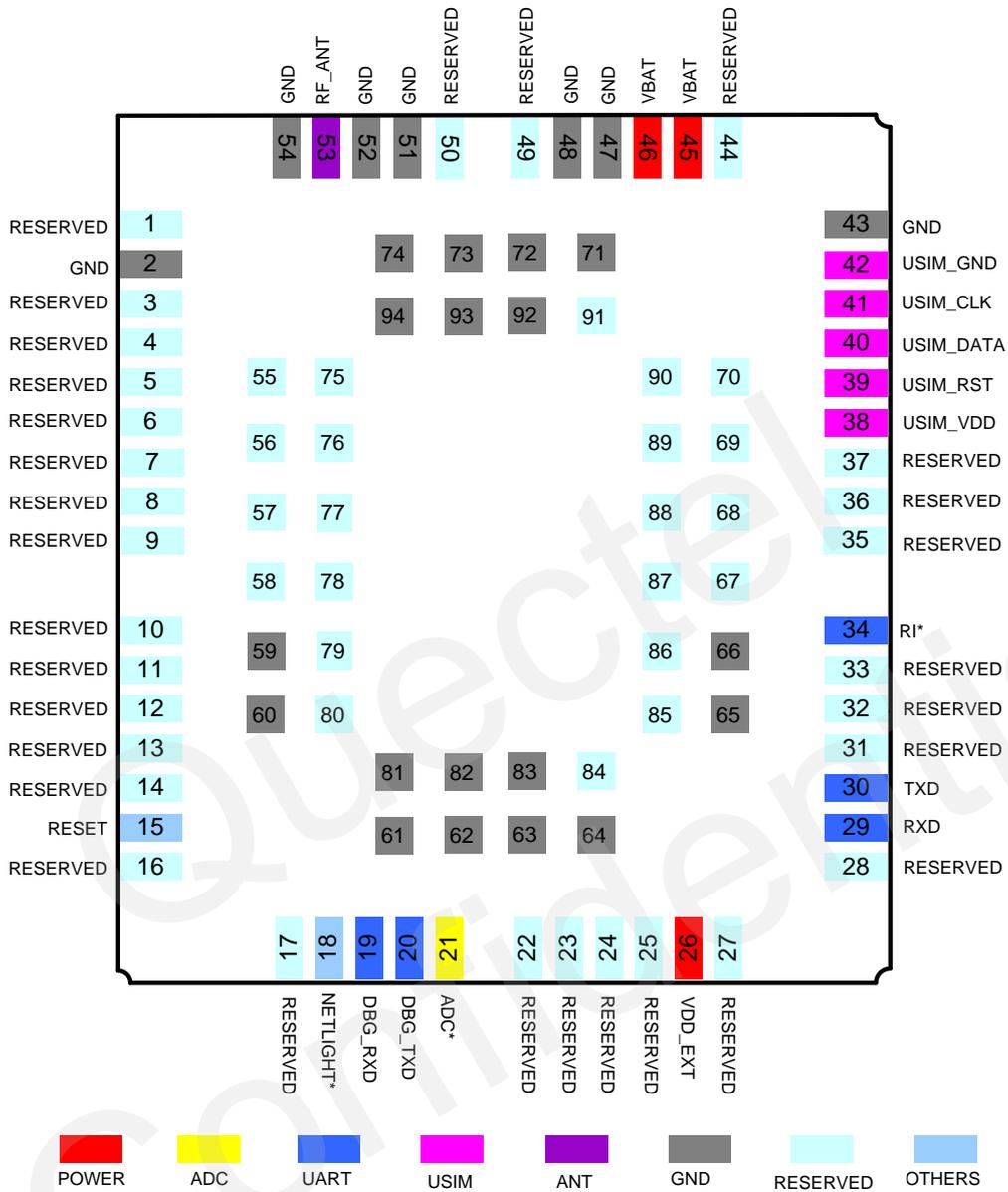


Figure 2: Pin Assignment

NOTE

“*” means under development.

3.3. Pin Description

The following tables show the pin definition and description of BC95.

Table 3: I/O Parameters Definition

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
PI	Power input
PO	Power output
AI	Analog input
AO	Analog output
OD	Open drain

Table 4: Pin Description

Power Supply					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VBAT	45, 46	PI	Main power supply of the module: VBAT=3.1V~4.2V	Vmax=4.2V Vmin=3.1V Vnorm=3.6V	The power supply must be able to provide sufficient current up to 0.5A.
VDD_EXT	26	PO	Supply 3.0V voltage for external circuit	Vnorm=3.0V I _o max=20mA	If unused, keep this pin open. Recommend to add a 2.2~4.7uF bypass capacitor when using this pin for power supply.
GND	2, 43, 47, 48, 51, 52,		Ground		

54,
59~66,
71~74,
81~83,
92~94

Reset Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESET	15	DI	Reset the module	$R_{PU} \approx 78k\Omega$ $V_{IHmax} = 3.3V$ $V_{IHmin} = 2.1V$ $V_{ILmax} = 0.6V$	Pull up internally. Active low.

Network Status Indicator

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
NETLIGHT*	18	DO	Network status indication	$V_{OLmax} = 0.4V$ $V_{OHmin} = 2.4V$	If unused, keep this pin open.

ADC Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
ADC*	21	AI	General purpose analog to digital converter interface	Input voltage range: 0V to VBAT	If unused, keep this pin open.

UART Port

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RXD	29	DI	Receive data	$V_{ILmax} = 0.6V$ $V_{IHmin} = 2.1V$ $V_{IHmax} = 3.3V$	3.0V power domain.
TXD	30	DO	Transmit data	$V_{OLmax} = 0.4V$ $V_{OHmin} = 2.4V$	3.0V power domain.
RI*	34	DO	Ring indicator	$V_{OLmax} = 0.4V$ $V_{OHmin} = 2.4V$	3.0V power domain. If unused, keep this pin open.

Debug Port

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
DBG_ RXD	19	DI	Receive data	$V_{ILmax} = 0.6V$ $V_{IHmin} = 2.1V$ $V_{IHmax} = 3.3V$	If unused, keep these pins open.

DBG_ TXD	20	DO	Transmit data	$V_{OLmax}=0.4V$ $V_{OHmin}=2.4V$	If unused, keep these pins open.
-------------	----	----	---------------	--------------------------------------	----------------------------------

USIM Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
USIM_ VDD	38	DO	Power supply for USIM card	$V_{norm}=3.0V$	
USIM_ RST	39	DO	USIM card reset	$V_{OLmax}=0.4V$ $V_{OHmin}=2.4V$	All signals of USIM interface should be protected against ESD with a TVS diode array. Maximum trace length from the module pad to USIM card connector is 200mm.
USIM_ DATA	40	IO	USIM card data	$V_{OLmax}=0.4V$ $V_{OHmin}=2.4V$ $V_{ILmin}=-0.3V$ $V_{ILmax}=0.6V$ $V_{IHmin}=2.1V$ $V_{IHmax}=3.3V$	
USIM_ CLK	41	DO	USIM card clock	$V_{OLmax}=0.4V$ $V_{OHmin}=2.4V$	
USIM_ GND	42		USIM card ground		

RF Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RF_ANT	53	IO	RF antenna pad	Impedance of 50Ω	

RESERVED Pins

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESERVED	1, 3~14, 16, 17, 22, 23, 24, 25, 27, 28, 31~33, 35~37, 44, 49, 50, 55~58, 67~70, 75~80, 84~91		Reserved		Keep these pins unconnected.

NOTE

“*” means under development.

3.4. Operating Modes

BC95 module has three operating modes, which can determine availability of functions for different levels of power-saving.

Table 5: Overview of Operating Modes

Mode	Function	
Normal Operation	Active	In active mode, all functions of the module are available and all processors are active. Radio transmission and reception can be performed. Transitions to idle mode or PSM can be initiated in active mode.
	Idle	In idle mode, the module is in light sleep and network connection is maintained; paging messages can be received; transitions to active mode or PSM can be initiated in idle mode.
	PSM	In PSM, only the 32kHz RTC is working. The network is disconnected, and paging messages cannot be received either. When MO (Mobile Originated) data are sent or the periodic TAU (Tracking Area Update) timer T3412 expires, the module will be woken up.

3.5. Power Supply

3.5.1. Power Supply Pins

BC95 provides two VBAT pins for connection with an external power supply.

The following table shows the VBAT pins and ground pins.

Table 6: VBAT and GND Pins

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT	45, 46	Power supply for the module	3.1	3.6	4.2	V

	2, 43, 47, 48, 51, 52,				
GND	54, 59~66, 71~74, Ground 81~83, 92~94	-	0	-	V

3.5.2. Reference Design for Power Supply

The power design for the module is very important, as the performance of the module largely depends on the power source. A Low quiescent current LDO which can provide sufficient input current up to 0.5A can be used as the power supply. Meanwhile, Li-SOC12 batteries can also be used to supply power for the module. The power supply range of the module is from 3.1V to 4.2V. Please make sure that the input voltage will never drop below 3.1V even in burst transmission. If the power voltage drops below 3.1V, the module will be abnormal.

For better power performance, it is recommended to place a 100uF tantalum capacitor with low ESR (ESR=0.7Ω) and three ceramic capacitors with 100nF, 100pF and 22pF near the VBAT pin. A reference circuit is illustrated in the following figure. In principle, the longer the VBAT trace is, the wider it will be.

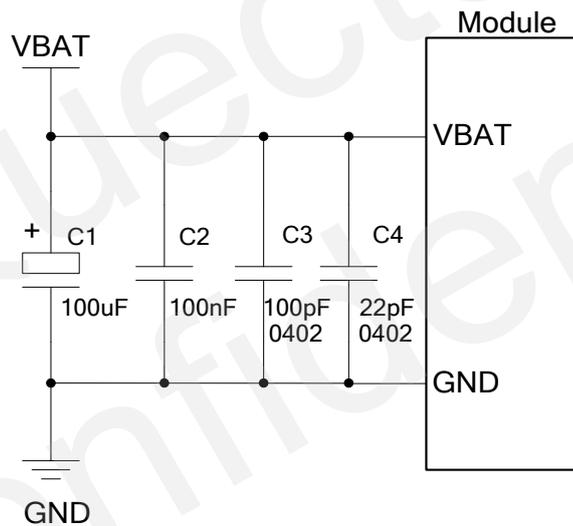


Figure 3: Reference Circuit for the VBAT Input

3.6. Power on and down Scenarios

3.6.1. Power on

The module can be automatically turned on by supplying power source to VBAT pins.

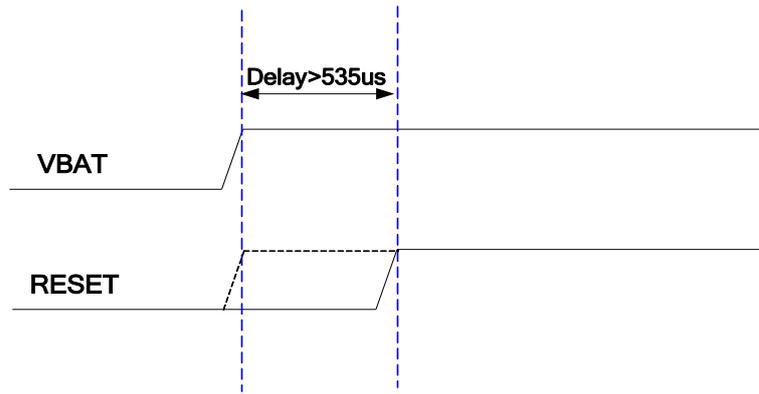


Figure 4: Turn-on Timing

3.6.2. Power down

The module can be turned off by shutting down the VBAT power supply.

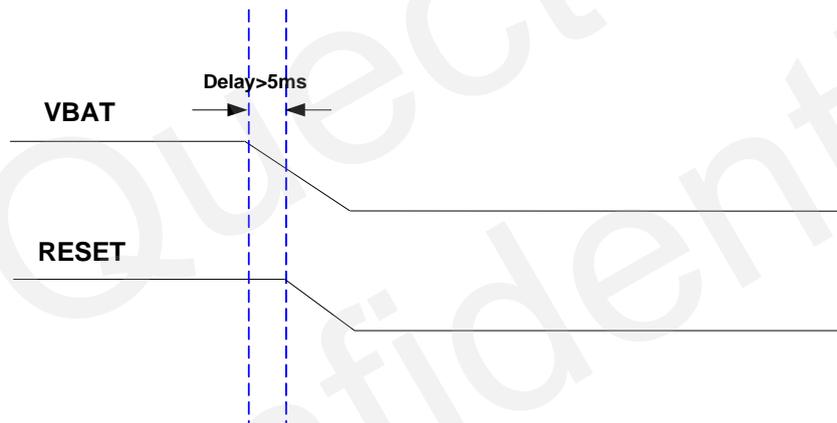


Figure 5: Turn-off Timing

3.6.3. Reset the Module

The module can be reset by two ways. The reset timing is illustrated as the following table.

- **Hardware**

Reset the module by driving the reset pin to a low level voltage for a certain time.

- **Software**

Reset the module using command “**AT+NRB**”, please refer to *document [5]*.

Table 7: Reset Characteristics

Pin Name	Pin No.	Description	Reset Time
RESET	15	Reset the module, active low	>100ms

The recommended circuit of hardware resetting is shown as below. An open drain/collector driver or button can be used to control the RESET pin.

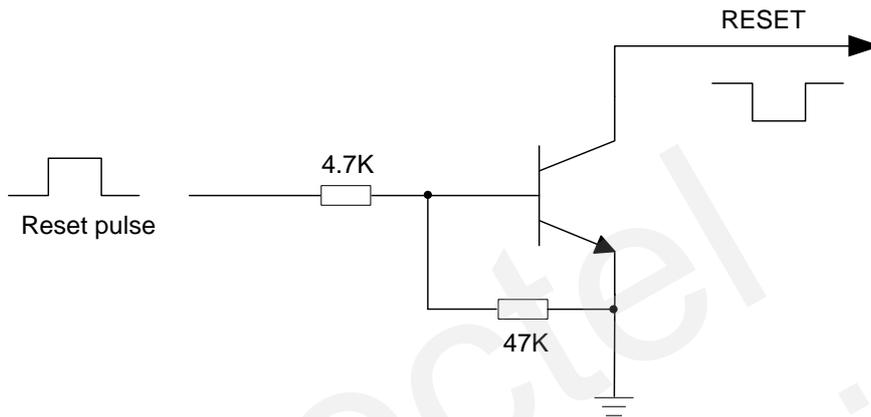


Figure 6: Reference Circuit of RESET by Using Driving Circuit

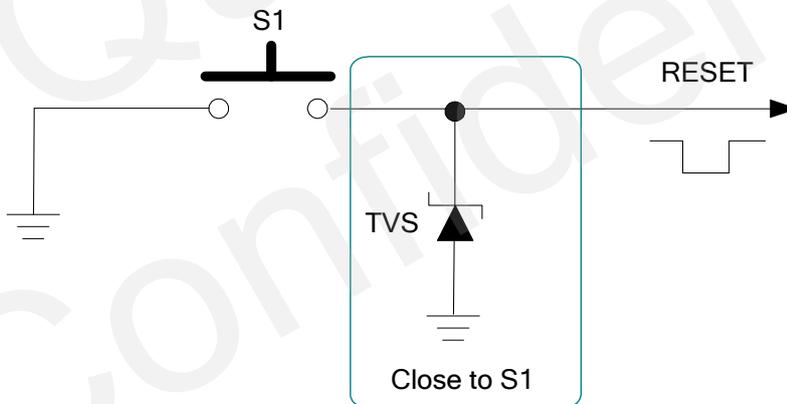


Figure 7: Reference Circuit of RESET by Using Button

3.7. Power Saving

Based on system performance, the module consumes a maximum current of 5uA in PSM. PSM was designed to reduce power consumption of the module and improve battery life. The following figure shows the power consumption of the module in different modes.

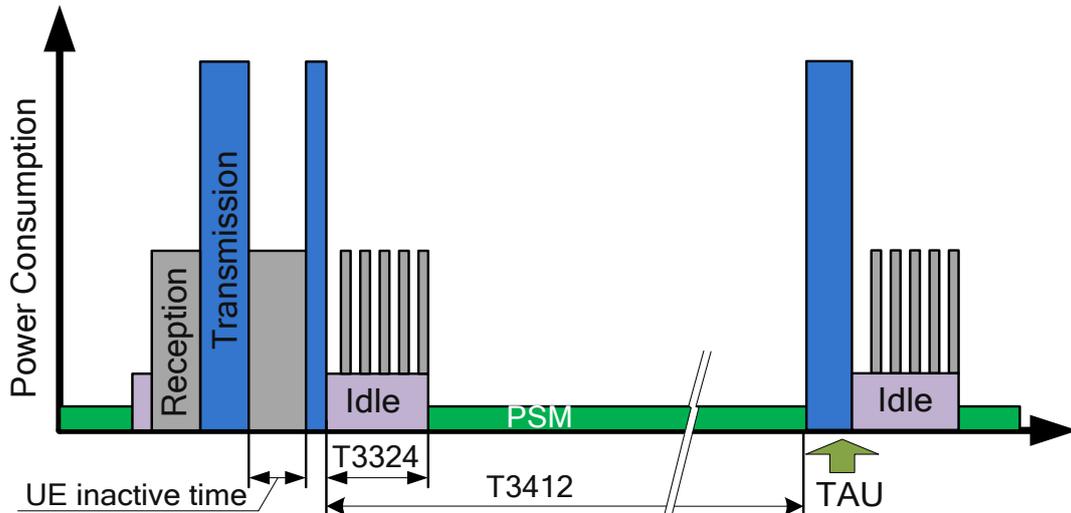


Figure 8: Diagram for Power Consumption

The procedure for entering PSM is as follows: the module 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 module and the mobile reachable timer starts. When the T3324 timer expires, the module enters PSM for duration of T3412 (periodic TAU timer). Please 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 PSM, it cannot be paged and stops access stratum activities such as cell reselection, and T3412 is still active.

When MO (Mobile Originated) data are sent or the periodic TAU timer expires, the module will exit from PSM.

3.8. UART Interfaces

The module provides two UART ports: main port and debug port. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection.

The main port:

- TXD: Send data to RXD of DTE.
- RXD: Receive data from TXD of DTE.
- RI*: Ring indicator (when an SMS message is received or data is transmitted, the module will output signals to inform DTE).

The debug port:

- DBG_TXD: Send data to the COM port of computer.
- DBG_RXD: Receive data from the COM port of computer.

NOTE

“*” means under development.

The logic levels are described in the following table.

Table 8: Pin Definition of the UART Interfaces

Interfaces	Pin No.	Pin Name	Description	Comment
Debug Port	19	DBG_RXD	Receive data	3.0V power domain
	20	DBG_TXD	Transmit data	3.0V power domain
Main Port	29	RXD	Receive data	3.0V power domain
	30	TXD	Transmit data	3.0V power domain
	34	RI	Ring indicator	3.0V power domain

Table 9: Logic Levels of the UART Interfaces

Parameter	Min.	Max.	Unit
V _{IL}	-0.1 × VDD_EXT	0.2 × VDD_EXT	V
V _{IH}	0.7 × VDD_EXT	1.1 × VDD_EXT	V
V _{OL}		0.4	V
V _{OH}	2.4	VDD_EXT	V

3.8.1. Main Port

Main port can be used for AT command communication and data transmission, and the baud rate is 9600bps. It can also be used for firmware upgrading through Universal Code Loader or Code Loader tool, and the baud rate for firmware upgrading is 115200bps. This main port is available in active mode, idle mode and PSM. For details, please refer to **document [2] & [3]**.

The following figure shows the connection between the DCE and DTE.

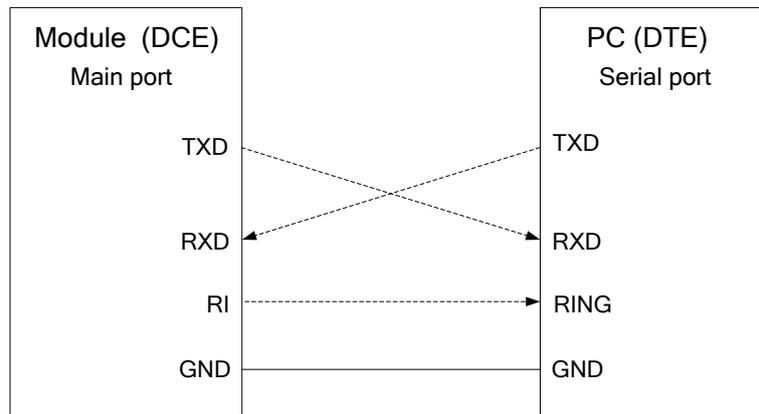


Figure 9: Reference Design for Main Port

3.8.2. Debug Port

Debug port is used to view log information with UE Log Viewer tool for debugging, and the baud rate is 921600bps.

A reference design for debug port is shown as below.

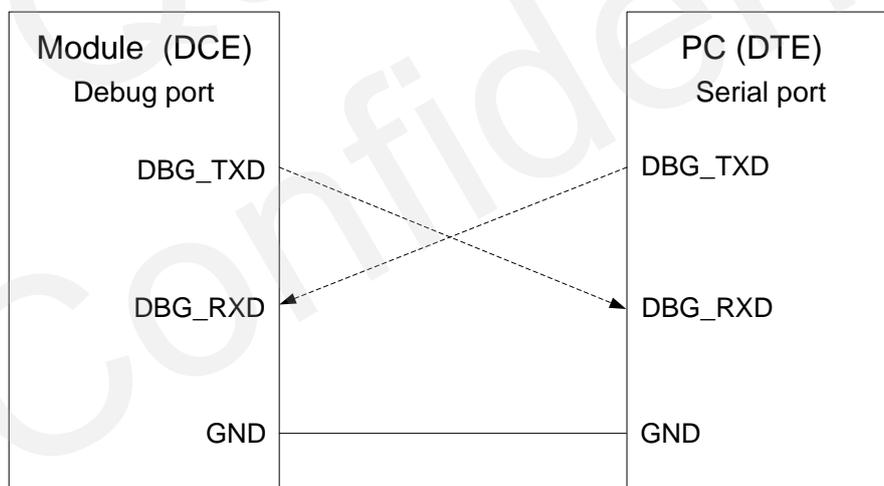


Figure 10: Reference Design for Debug Port

3.8.3. UART Application

A reference design of 3.3V level match is shown as below.

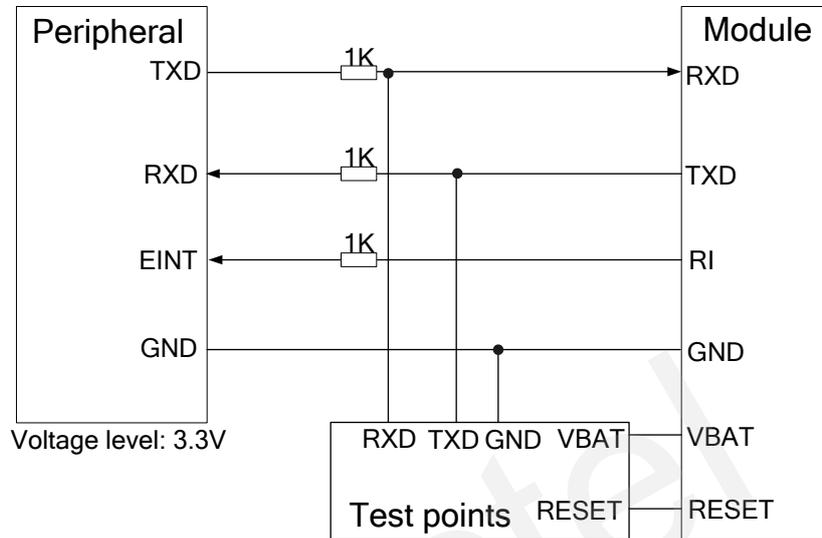


Figure 11: Level Match Design for 3.3V System

NOTE

1. In order to reduce the power consumption of the system, it is highly recommended to add a resistor with resistance greater than 1K Ω on the UART port signal traces when the host's voltage level is 3V or 3.3V.
2. For systems with a higher voltage level, a level shifter IC could be used between the host and the module.
3. It is recommended to reserve the test points (RXD, TXD, RESET and VBAT) for firmware upgrading.

The following circuit shows a reference design for the communication between module and PC. As the electrical level of module is 3.0V, a RS-232 level shifter must be used. Please make sure the I/O voltage of level shifter which connects to module is 3.0V.

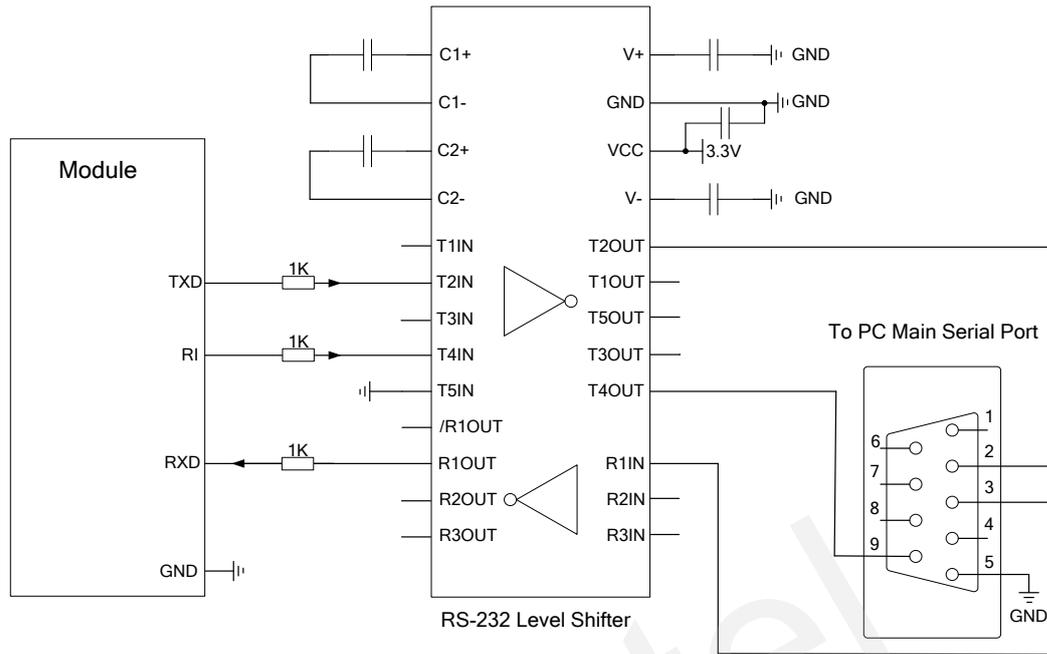


Figure 12: Sketch Map for RS-232 Interface Match

Please visit vendor web site to select the suitable RS-232 level shifter IC, such as: <http://www.exar.com> and <http://www.maximintegrated.com>.

3.9. USIM Card Interface

The module contains one USIM interface to allow the module to access the USIM card.

3.9.1. USIM Card Application

The USIM card interface supports the functionality of the 3GPP specification, which is intended for use with a USIM application tool-kit.

The USIM card interface is powered by an internal regulator in the module. Only 3.0V USIM card is supported.

Table 10: Pin Definition of the USIM Card Interface

Pin No.	Pin Name	Description
38	USIM_VDD	Supply power for USIM card. USIM card voltage domain is 3.0V±5%.

41	USIM_CLK	USIM card clock
40	USIM_DATA	USIM card data I/O
39	USIM_RST	USIM card reset
42	USIM_GND	USIM card ground

A reference circuit for 6-pin USIM card connector is illustrated as the following figure.

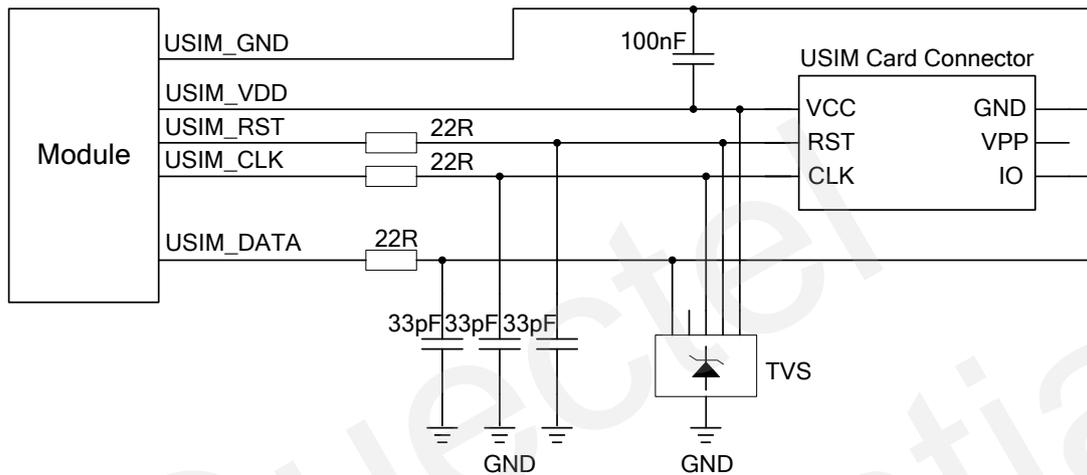


Figure 13: Reference Circuit for USIM Interface with 6-pin USIM Card Connector

For more information of USIM card connector, please visit <http://www.amphenol.com> and <http://www.molex.com>.

In order to enhance the reliability and availability of the USIM card in application, please follow the criteria below in USIM circuit design:

- Keep layout of USIM card to the module as close as possible. Keep the trace length as less than 200mm as possible.
- Keep USIM card signals away from RF and VBAT traces.
- Assure the ground between module and USIM card connector short and wide. Keep the trace width of ground no less than 0.5mm to maintain the same electric potential. The decouple capacitor of USIM_VDD is less than 1uF and must be near to USIM card connector.
- To avoid cross talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array. For more information of TVS diode, please visit <http://www.onsemi.com>. The most important rule is to place the ESD protection device close to the USIM card connector and make sure the USIM card interface signal traces being protected will go through the ESD protection device first and then lead to the module. The 22Ω resistors should be connected in series between the module and the USIM card so

as to suppress EMI spurious transmission and enhance ESD protection. Please note that the USIM peripheral circuit should be close to the USIM card connector.

- Place the RF bypass capacitors (33pF) close to the USIM card on all signals traces to improve EMI suppression.

3.10. ADC Interface*

The module provides a 10-bit ADC input channel to read the voltage value. This ADC interface is available in active mode and idle mode.

Table 11: Pin Definition of the ADC

Pin Name	Pin No.	Description
ADC	21	Analog to digital converter interface

NOTE

“*” means under development.

3.11. Behaviors of RI*

When an SMS message is received or certain URCs are reported, RI pin will be triggered. The behaviors of RI are shown as below.

Table 12: Behaviors of RI

State	RI Response
Idle	HIGH
SMS*	When an SMS message is received, the RI is changed to LOW and kept at low level for about 120ms. Then it is changed to HIGH.
URC	Certain URCs can trigger RI to LOW for 120ms. Then it is changed to HIGH.

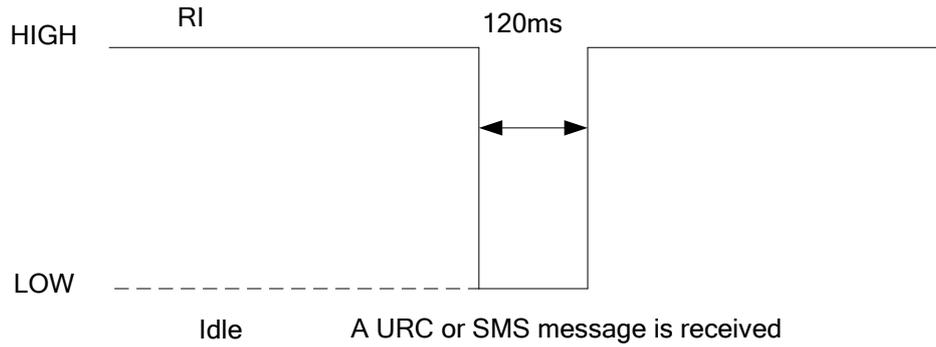


Figure 14: Behaviors of RI When a URC or SMS Message is Received

NOTE

“*” means under development.

3.12. Network Status Indication*

The NETLIGHT signal can be used to drive a network status indication LED. The working state of this pin is listed in the following table.

Table 13: Working State of the NETLIGHT

State	Module Function
Low (Light off)	The module is not working or not attached to network.
High (Light on)	The module is attached to network.

A reference circuit is shown as below.

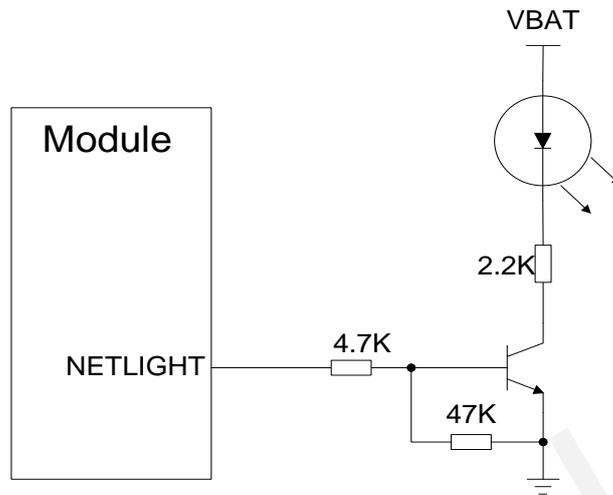


Figure 15: Reference Design for NETLIGHT

NOTE

“*” means under development.

4 Antenna Interface

The pin 53 is the RF antenna pad. The RF antenna interface has an impedance of 50Ω.

Table 14: Pin Definition of the RF Antenna Interface

Pin Name	Pin No.	Description
GND	51	Ground
GND	52	Ground
RF_ANT	53	RF antenna pad
GND	54	Ground

4.1. RF Antenna Reference Design

A reference design for RF antenna is shown as below.

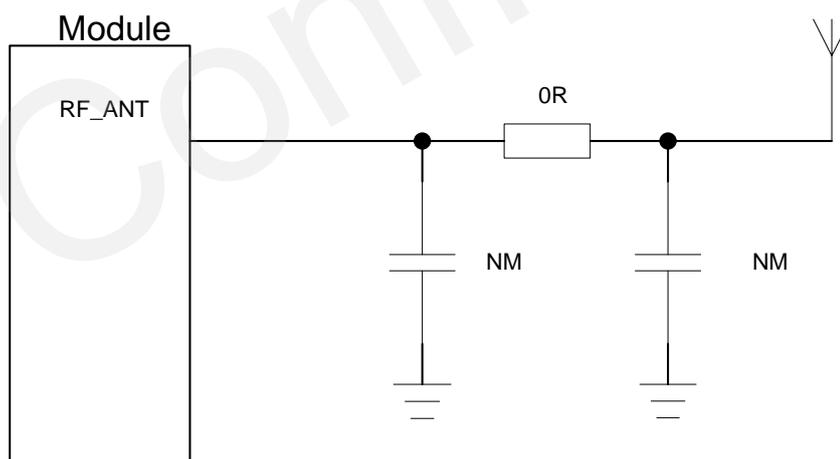


Figure 16: Reference Design for RF Antenna

BC95 provides an RF antenna pad for antenna connection. There is one grounding pad on both sides of the antenna pad in order to give a better grounding. Besides, a π -type match circuit is suggested to be used to adjust the RF performance, and place the π -type matching components as close to the antenna as possible.

4.2. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as 50 ohm. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the distance between signal layer and reference ground (H), and the clearance between RF trace and ground (S). Microstrip line or coplanar waveguide line is typically used in RF layout for characteristic impedance control. The following are reference designs of microstrip line or coplanar waveguide line with different PCB structures.

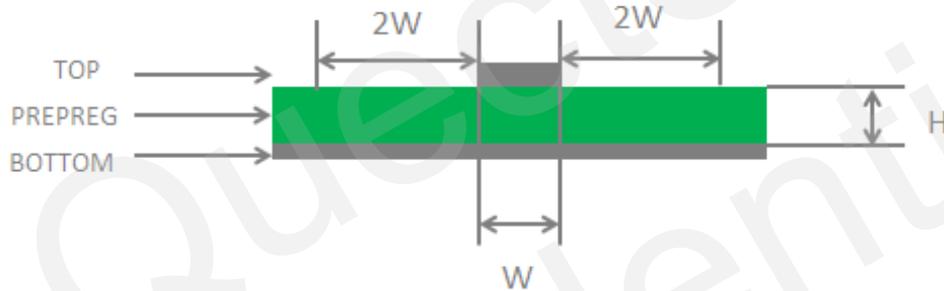


Figure 17: Microstrip Line Design on a 2-layer PCB

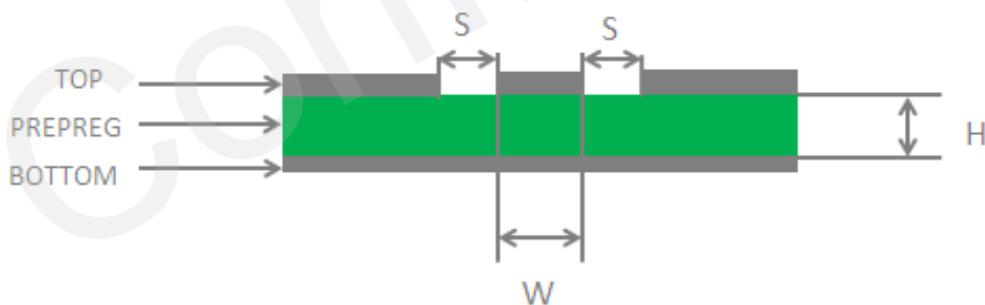


Figure 18: Coplanar Waveguide Line Design on a 2-layer PCB

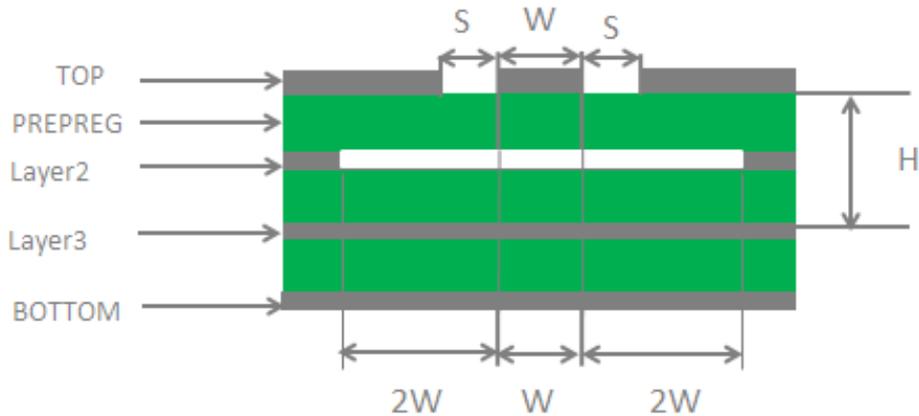


Figure 19: Coplanar Waveguide Line Design on a 4-layer PCB (Layer 3 as Reference Ground)

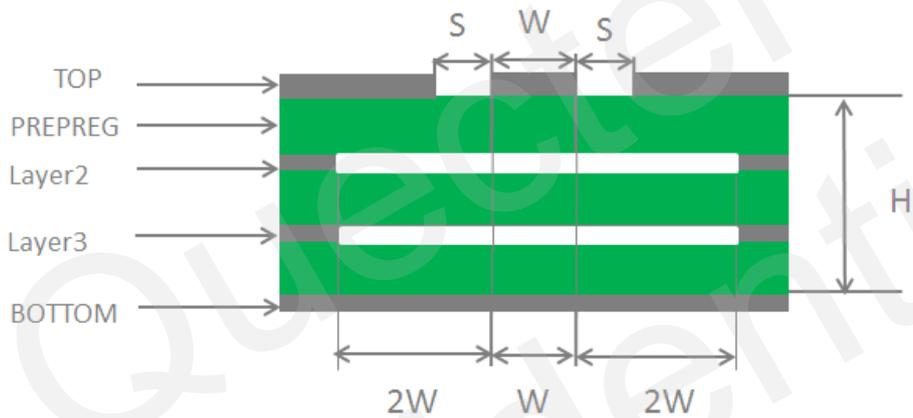


Figure 20: Coplanar Waveguide Line Design on a 4-layer PCB (Layer 4 as Reference Ground)

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

- Use impedance simulation tool to control the characteristic impedance of RF traces as 50 ohm.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- The distance between the RF pins and the RF connector should be as short as possible, and all the right angle traces should be changed to curved ones.
- There should be clearance area 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 about RF layout, please refer to **document [4]**.

4.3. RF Output Power

Table 15: RF Output Power (Uplink QPSK and BPSK Modulation)

Frequency Band	Max.	Min.
Band 8	23dBm±2dB	<-40dBm
Band 5	23dBm±2dB	<-40dBm
Band 20	23dBm±2dB	<-40dBm
Band 28	23dBm±2dB	<-40dBm

NOTE

This design is compliant with the NB-IoT radio protocol *3GPP Rel-13*.

4.4. RF Receiving Sensitivity

Table 16: RF Receiving Sensitivity (Throughput ≥ 95%)

Frequency Band	Receiving Sensitivity
Band 8	-129dBm±1dB
Band 5	-129dBm±1dB
Band 20	-129dBm±1dB
Band 28	-129dBm±1dB

4.5. Operating Frequencies

Table 17: Operating Frequencies

Frequency Band	Receive	Transmit
Band 8	925~960MHz	880~915MHz
Band 5	869~894MHz	824~849MHz
Band 20	791~821MHz	832~862MHz
Band 28	758~803MHz	703~748MHz

4.6. Antenna Requirement

The following table shows the requirement on NB-IoT antenna.

Table 18: Antenna Cable Requirement

Frequency Range	Requirement
758-960MHz	Insertion Loss: <1dB

Table 19: Antenna Requirements

Type	Requirements
Frequency Range	758-960MHz
VSWR	≤2
Gain (dBi)	≥1
Max Input Power (W)	5
Input Impedance (Ω)	50
Polarization Type	Linear

4.7. Install the Antenna with RF Connector

The following figure is the antenna installation with RF connector provided by HIROSE. The recommended RF connector is UF.L-R-SMT.

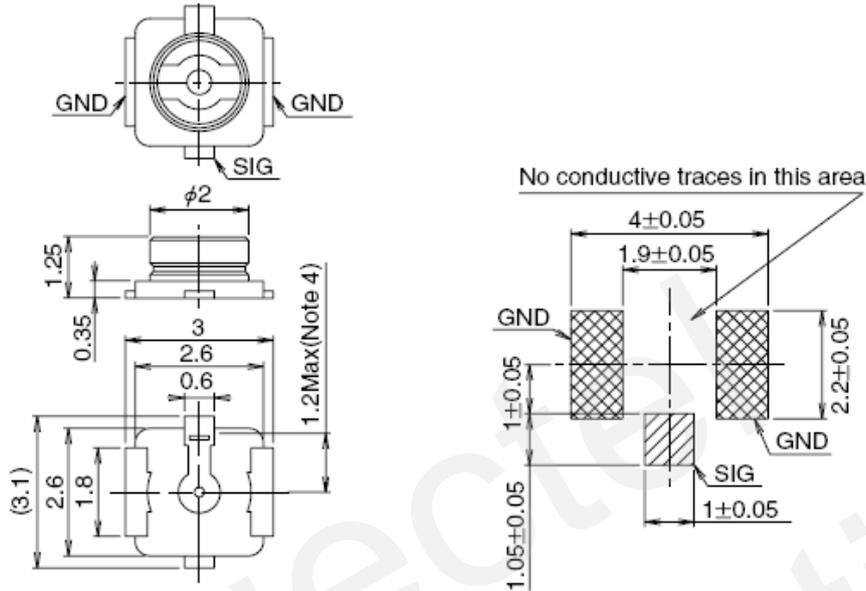


Figure 21: Dimensions of the UF.L-R-SMT Connector (Unit: mm)

U.FL-LP series connector listed in the following figure can be used to match the UF.L-R-SMT.

	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
Part No.					
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 22: Mechanicals of UF.L-LP Connectors

The following figure describes the space factor of mated connector.

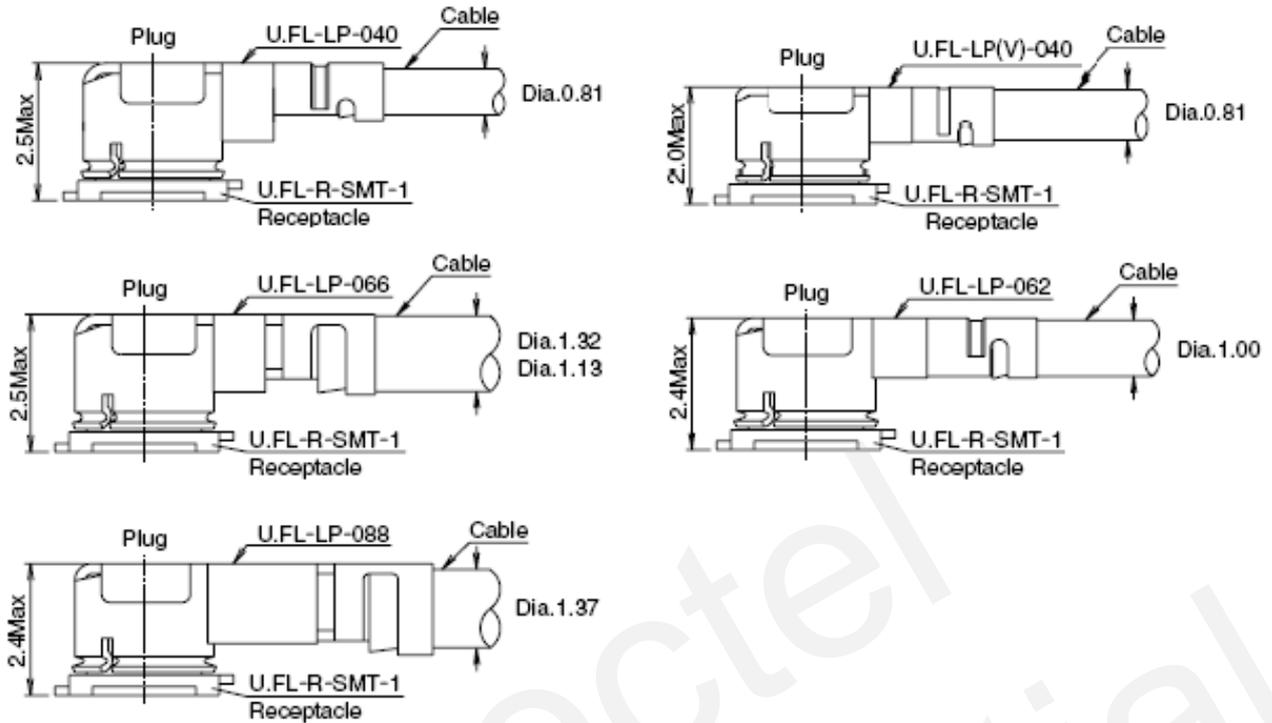


Figure 23: Space Factor of Mated Connector (Unit: mm)

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 20: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT	-0.3	+4.25	V
Current of Power Supply	0	0.3	A
Voltage at Digital Pins	-0.3	+3.3	V
Voltage at Analog Pins	-0.3	+4.25	V
Voltage at Digital/Analog Pins in Power Down Mode	-0.25	+0.25	V

5.2. Operating Temperature

The operating temperature is listed in the following table.

Table 21: Operating Temperature

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range ¹⁾	-30	+25	+75	°C
Extended Temperature Range ²⁾	-40		+85	°C

NOTES

1. ¹⁾ Within operation temperature range, the module is 3GPP compliant.
2. ²⁾ Within extended temperature range, the module remains the ability to establish and maintain an SMS*, data transmission, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.
3. “*” means under development.

5.3. Current Consumption

The values of current consumption are shown below.

Table 22: Current Consumption

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit	
I _{VBAT}	PSM	Deep sleep state		3	5	uA	
	Idle mode	Standby state		6		mA	
	Active mode	Radio transmission (23dBm)			230		mA
		Radio reception			61		mA

5.4. Electrostatic Discharge

The module is not protected against electrostatic 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 23: Electrostatic Discharge Characteristics

Test Points	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 mm. The tolerances for dimensions without tolerance values are $\pm 0.05\text{mm}$.

6.1. Mechanical Dimensions of the Module

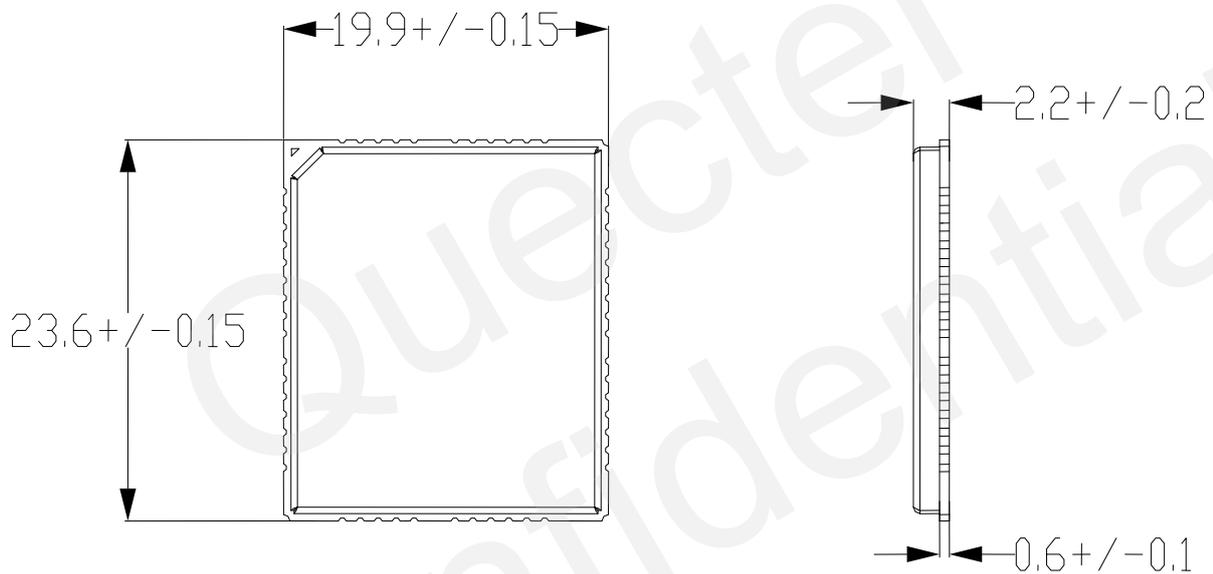


Figure 24: Module Top and Side Dimensions

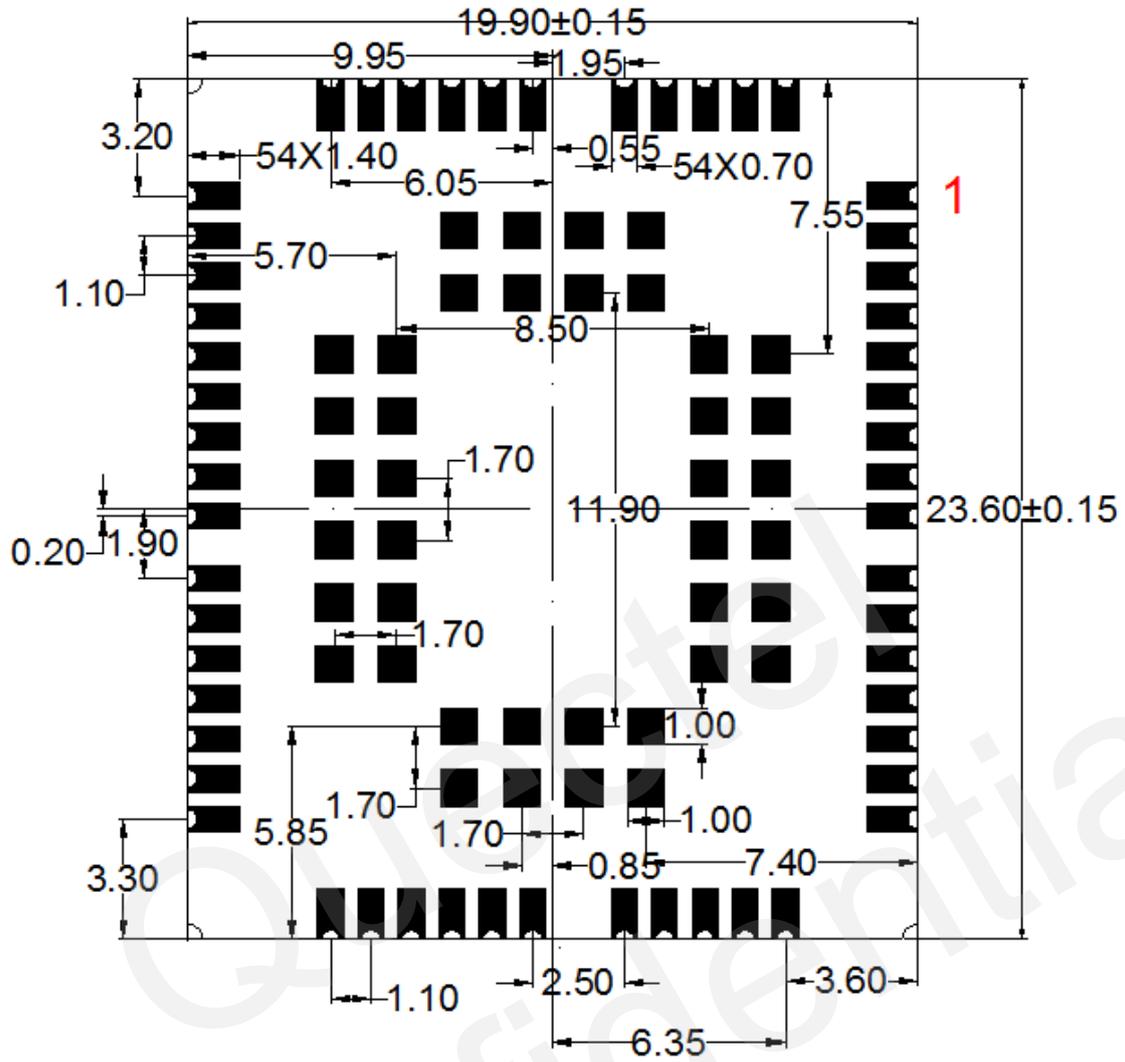


Figure 25: Module Bottom Dimensions (Bottom View)

6.2. Recommended Footprint

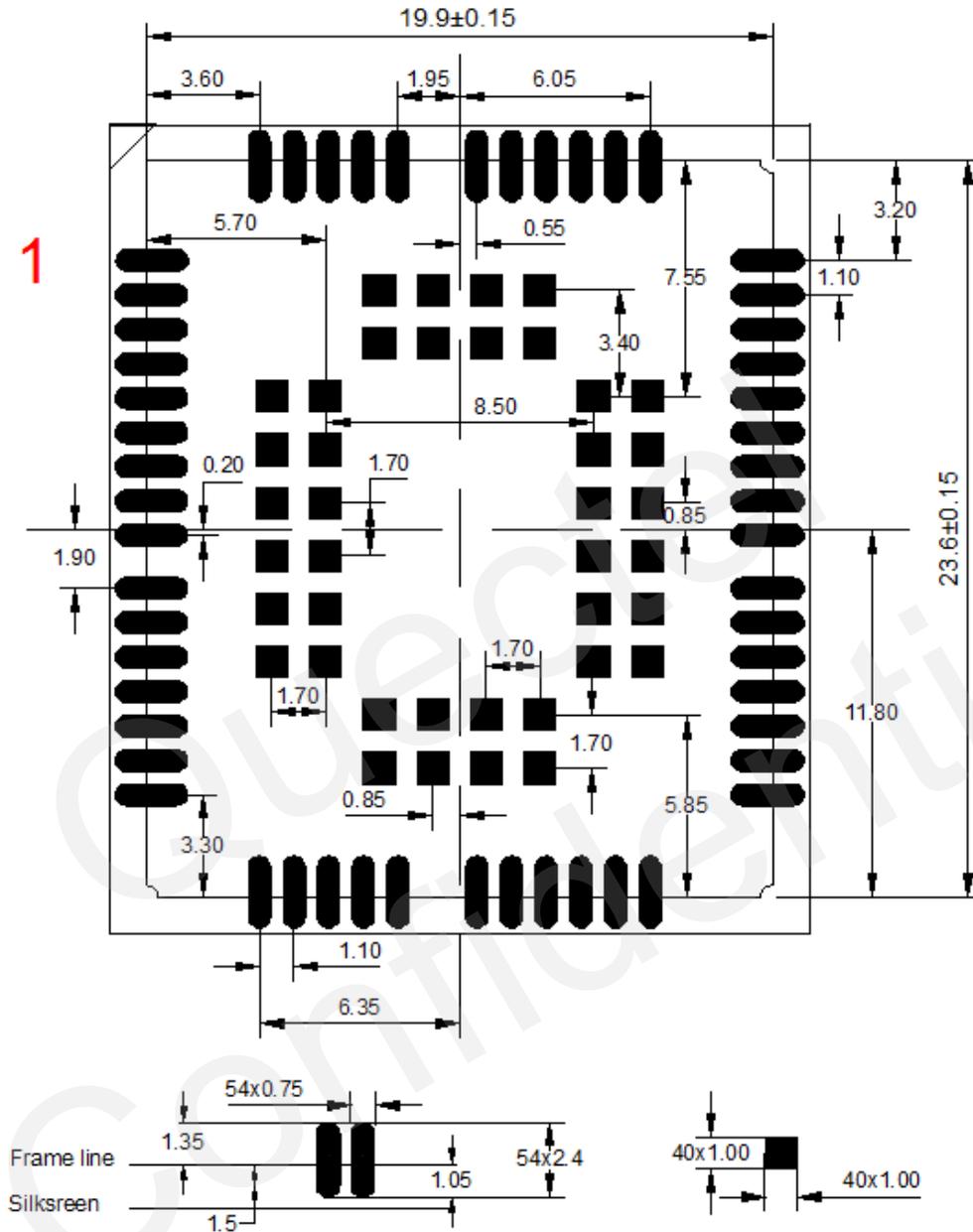


Figure 26: Recommended Footprint (Top View)

NOTES

1. For easy maintenance of the module, please keep about 3mm between the module and other components in the host PCB.
2. All RESERVED pins must not be connected to GND.

6.3. Design Effect Drawings of the Module



Figure 27: Top View of the Module

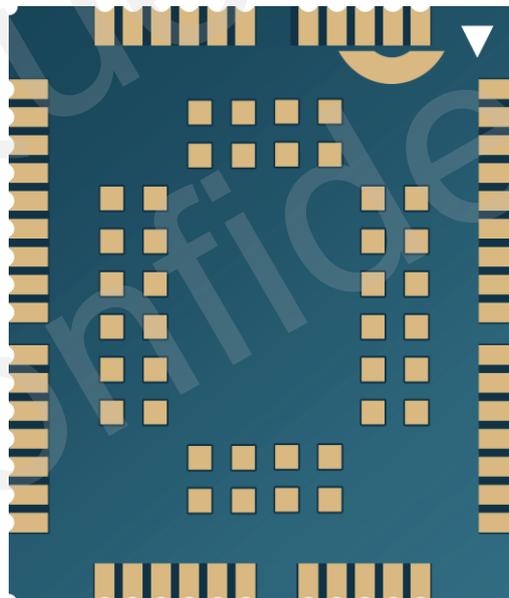


Figure 28: Bottom View of the Module

NOTE

These are design effect drawings of BC95 module. For more accurate pictures, please refer to the module that you get from Quectel.

7 Storage, Manufacturing and Packaging

7.1. Storage

BC95 module is stored in a vacuum-sealed bag. The storage restrictions are shown as below.

1. Shelf life in the vacuum-sealed bag: 12 months at <math><40^{\circ}\text{C}/90\%\text{RH}</math>.
2. After the vacuum-sealed bag is opened, devices that will be subjected to reflow soldering or other high temperature processes must be:
 - Mounted within 168 hours at the factory environment of $\leq 30^{\circ}\text{C}/60\% \text{RH}$.
 - Stored at <math><10\% \text{RH}</math>.
3. Devices require baking before mounting, if any circumstance below occurs:
 - When the ambient temperature is $23^{\circ}\text{C}\pm 5^{\circ}\text{C}$ and the humidity indication card shows the humidity is $>10\%$ before opening the vacuum-sealed bag.
 - Device mounting cannot be finished within 168 hours at factory conditions of $\leq 30^{\circ}\text{C}/60\%$
4. If baking is required, devices may be baked for 48 hours at $125^{\circ}\text{C}\pm 5^{\circ}\text{C}$.

NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature (125°C) baking. If shorter baking time is desired, please refer to the *IPC/JEDECJ-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 0.15mm. For more details, please refer to **document [1]**.

It is suggested that the peak reflow temperature is 235 ~ 245°C (for SnAg3.0Cu0.5 alloy). The absolute max reflow temperature is 260°C. To avoid damage to the module caused by repeatedly heating, it is suggested that the module should be mounted after reflow soldering for the other side of PCB has been completed. Recommended reflow soldering thermal profile is shown below.

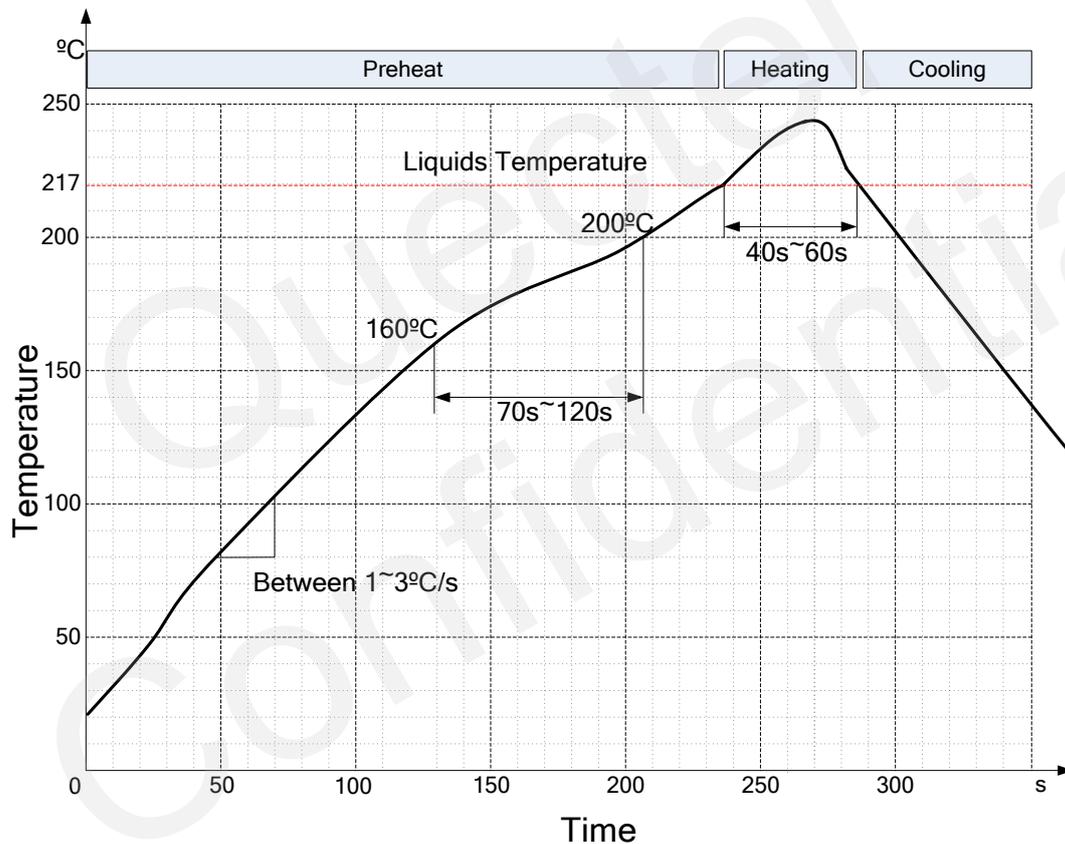


Figure 29: Reflow Soldering Thermal Profile

7.3. Packaging

The modules are stored inside a vacuum-sealed bag which is ESD protected. It 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 330mm in diameter and each reel contains 250 modules.

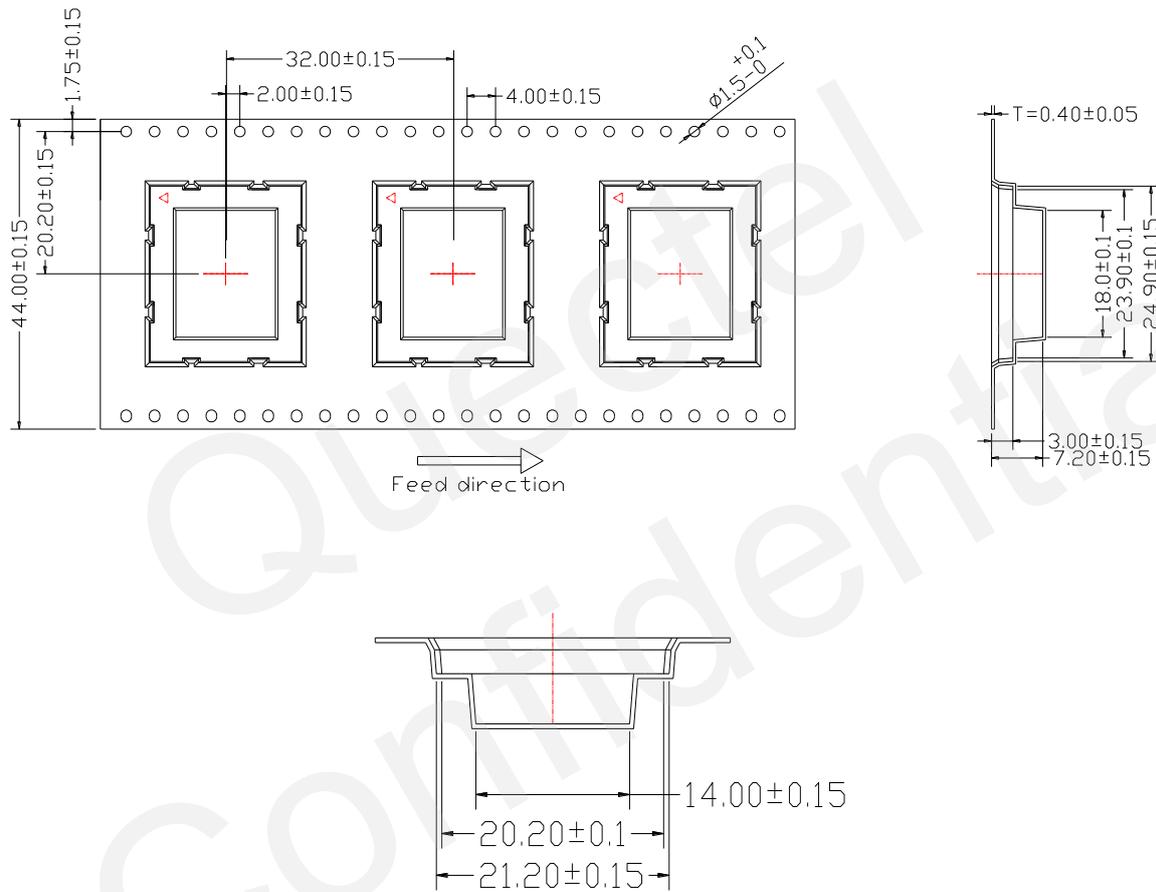


Figure 30: Tape Dimensions

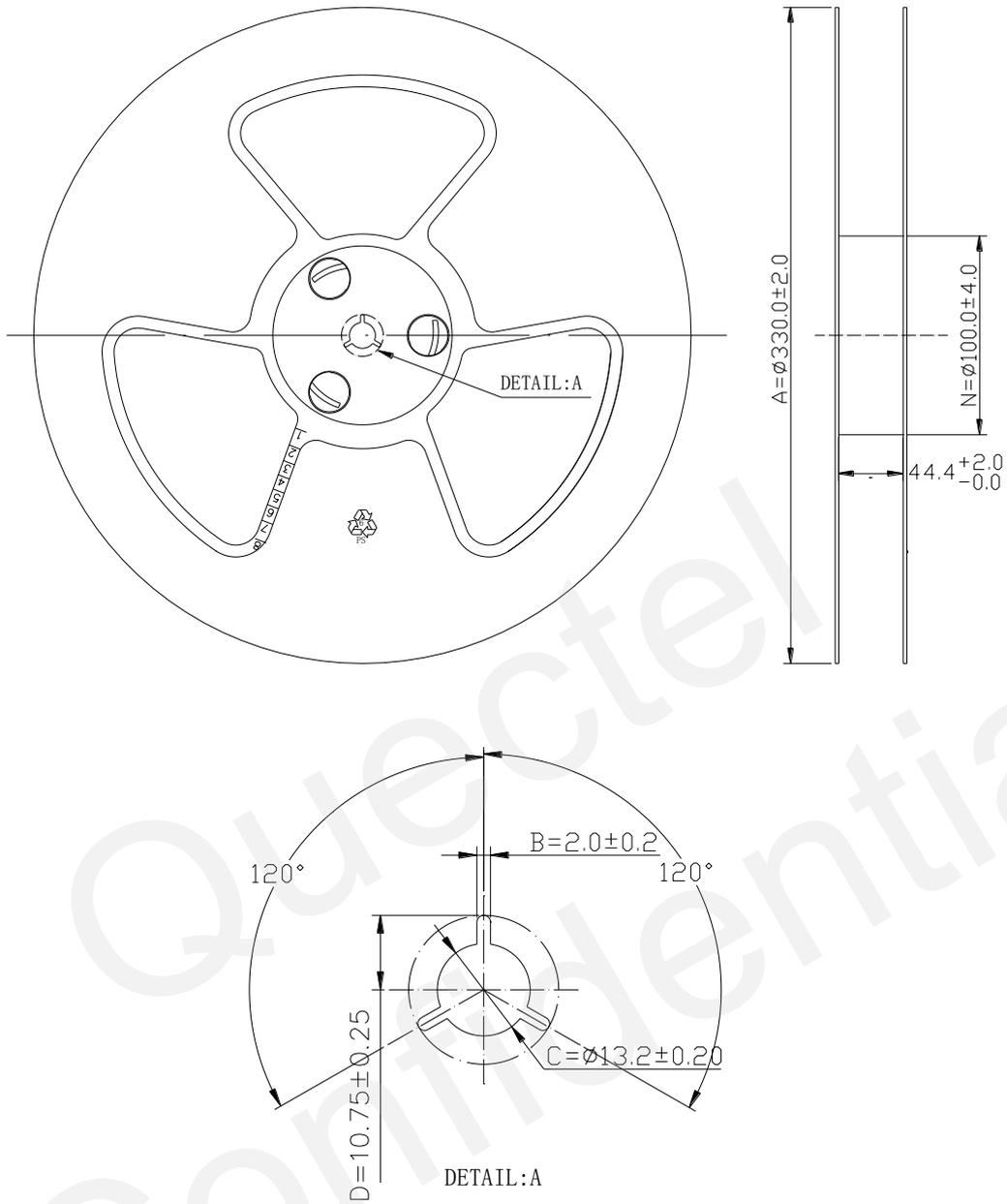


Figure 31: Reel Dimensions

8 Appendix A References

Table 24: Related Documents

SN	Document Name	Remark
[1]	Quectel_Module_Secondary_SMT_User_Guide	Module Secondary SMT User Guide
[2]	Quectel_BC95_Firmware_Upgrade_via_Code_Loader_User_Guide	BC95 Firmware Upgrade via Code Loader User Guide
[3]	Quectel_BC95_Firmware_Upgrade_via_Universal_Code_Loader_User_Guide	BC95 Firmware Upgrade via Universal Code Loader User Guide
[4]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[5]	Quectel_BC95_AT_Commands_Manual	BC95 AT Commands Manual

Table 25: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AS	Access Stratum
DCE	Data Communications Equipment (typically module)
DTE	Data Terminal Equipment (typically computer, external controller)
DRX	Discontinuous Reception
H-FDD	Half Frequency Division Duplexing
I/O	Input/Output
IC	Integrated Circuit
Imax	Maximum Load Current
Inorm	Normal Current

kbps	Kilo Bits Per Second
LED	Light Emitting Diode
MME	Mobility Management Entity
MO	Mobile Originated
NB-IoT	Narrow Band Internet of Things
PCB	Printed Circuit Board
PDN	Public Data Network
PSM	Power Saving Mode
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RTC	Real Time Clock
RX	Receive Direction
USIM	Universal Subscriber Identification Module
SMS	Short Message Service
TAU	Tracking Area Update
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
VSWR	Voltage Standing Wave Ratio
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value

VILmax	Maximum Input Low Level Voltage Value
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value

Quectel
Confidential