

# UG96 Hardware Design

**UMTS/HSPA Module Series**

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# About the Document

## History

Revision	Date	Author	Description
1.0	2015-02-28	Tony GAO/ Cat WANG	Initial
1.1	2015-10-23	Felix YIN	1. Updated PCM interface information in Table 2. 2. Updated Figure 1. 3. Updated PCM application in Chapter 3.13. 4. Updated ESD values in Chapter 5.7.
1.2	2015-12-08	Felix YIN	1. Updated GPRS/EDGE data features-class33 in Table 2. 2. Updated PCM timing in Chapter 3.13. 3. Updated current consumption values in Chapter 5.4. 4. Updated GPRS multi-slot class in Chapter 10.
1.3	2017-05-24	Eden LIU	1. Updated notes of PCM and I2C interfaces in Chapter 3.13. 2. Updated recommended footprint and stencil in Chapter 6.
1.4	2017-12-21	Yeoman CHEN	Modified TVS parasitic capacitance which should be less than 15pF for better performance in Chapter 3.11.
1.5	2018-01-12	Yeoman CHEN	Modified baking time and temperature of the module in Chapter 7.1.

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# 1 Introduction

This document defines the UG96 module and describes its air interface and hardware interface which are connected with customers' applications.

This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of UG96 module. Associated with application note and user guide, customers can use UG96 module to design and set up mobile applications easily.

## 1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating UG96 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 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

UG96 module is an embedded 3G wireless communication module, supports GSM/GPRS/EDGE and UMTS/HSDPA/HSUPA networks. It can also provide voice functionality<sup>1)</sup> for customers' specific applications. UG96 offers a maximum data rate of 7.2Mbps on downlink and 5.76Mbps on uplink in HSPA mode. GPRS supports the coding schemes CS-1, CS-2, CS-3 and CS-4. EDGE supports CS1-4 and MCS1-9 coding schemes. The following table shows the frequency bands of UG96 module.

**Table 1: Frequency Bands of UG96 Module**

Module	GSM 850	EGSM 900	DCS 1800	PCS 1900	UMTS 800	UMTS 850	UMTS 900	UMTS 1900	UMTS 2100
UG96	√	√	√	√	√	√	√	√	√

#### NOTE

<sup>1)</sup> UG96 module includes **Data-only** and **Telematics** versions. **Data-only** version does not support voice function while **Telematics** version supports it.

More details about GPRS/EDGE multi-slot configuration and coding schemes, please refer to **Appendix B, C and D**.

With a compact profile of 26.5mm × 22.5mm × 2.2mm, UG96 can meet almost all requirements for M2M applications such as wireless POS, metering, telematics, security, industry PDA/PC and tablet, etc.

UG96 is an SMD type module, which can be embedded in application through its 102 LGA pads.

UG96 is integrated with internet service protocols like TCP, UDP and PPP. Extended AT commands have been developed for customers to use these internet service protocols easily.

## 2.2. Key Features

The following table describes the detailed features of UG96 module.

**Table 2: Key Features of UG96 Module**

Feature	Details
Power Supply	Supply voltage: 3.3V~4.3V Typical supply voltage: 3.8V
Frequency Bands	GSM 4-band: 850/900/1800/1900MHz UMTS 5-band: 800/850/900/1900/2100MHz
Transmission Data	HSDPA category 8: Max 7.2Mbps HSUPA category 6: Max 5.76Mbps UMTS: Max 384kbps (DL)/Max 384kbps (UL) EDGE: Max 296kbps (DL)/Max 236.8kbps (UL) GPRS: Max 107kbps (DL)/Max 85.6kbps (UL) CSD: 14.4kbps
Transmitting Power	Class 4 (33dBm±2dB) for GSM850 and EGSM900 Class 1 (30dBm±2dB) for DCS1800 and PCS1900 Class E2 (27dBm±3dB) for GSM850 and EGSM900 8-PSK Class E2 (26dBm±3dB) for DCS1800 and PCS1900 8-PSK Class 3 (24dBm+1.7/-3.7dB) for UMTS 800/850/900/1900/2100
HSPA/UMTS Features	Compliant with 3GPP Release 7 WCDMA data rate is corresponded with 3GPP R99/R4 384kbps on downlink and 384kbps on uplink Support both QPSK and 16-QAM modulation
GSM/GPRS/EDGE Data Features	<b>GPRS:</b> Support GPRS multi-slot class 33 Coding scheme: CS-1, CS-2, CS-3 and CS-4 Maximum of four Rx time slots per frame <b>EDGE:</b> Support EDGE multi-slot class 33 Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme) Downlink coding schemes: CS 1-4 and MCS 1-9 Uplink coding schemes: CS 1-4 and MCS 1-9 <b>CSD:</b> CSD transmission rates: 14.4kbps non-transparent Support Unstructured Supplementary Services Data (USSD)
Internet Protocol Features	Support TCP/UDP/PPP/MMS/HTTP/HTTPS/SMTP/SMTPS/FTP/NTP/NITZ/PING/SSL protocols

	Support the protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) usually used for PPP connections
SMS	Text and PDU mode Point-to-point MO and MT SMS cell broadcast SMS storage: (U)SIM card by default
(U)SIM Interface	Support (U)SIM card: 1.8V, 3.0V
PCM Interface	Used for audio function with external codec Support 16/32-bit modes with short frame synchronization Support master and slave modes
UART Interface	Support one UART interface <ul style="list-style-type: none"> <li>● 7-wire on UART interface, without DSR</li> <li>● Support RTS and CTS hardware flow control</li> <li>● Baud rate 300bps to 921600bps</li> <li>● Default autobauding 4800bps to 115200bps</li> <li>● Used for data transmission, AT command communication and firmware upgrade</li> <li>● Multiplexing function</li> </ul>
USB Interface	Compliant with USB 1.1/2.0 specification (slave only), the data transfer rate can reach up to 480Mbps Used for AT command communication, data transmission, software debugging and firmware upgrade Support USB drivers for Windows XP, Windows Vista, Windows 7/8/8.1/10, Linux 2.6/3.x/4.1, Android 4.x/5.x/6.0
AT Commands	Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands
Real Time Clock	Supported
Network Indication	One pin NETLIGHT to indicate network status
Antenna Interface	GSM/UMTS antenna, 50Ω
Physical Characteristics	Size: (22.5±0.15)mm × (26.5±0.15)mm × (2.2±0.2)mm Package: LGA Weight: approx. 3.1g
Temperature Range	Operation temperature range: -35°C ~ +75°C <sup>1)</sup> Extended temperature range: -40°C ~ +85°C <sup>2)</sup> Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	USB interface or UART interface
RoHS	All hardware components are fully compliant with EU RoHS directive

**NOTES**

1. <sup>1)</sup> Within operating temperature range, the module is 3GPP compliant.
2. <sup>2)</sup> Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, 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 normal operating temperature levels, the module will meet 3GPP specifications again.

## 2.3. Functional Diagram

The following figure shows a block diagram of UG96 and illustrates the major functional parts.

- RF transceiver
- Baseband
- DDR+NAND flash
- Radio frequency
- Peripheral interfaces
  - UART interface
  - (U)SIM interface
  - USB interface
  - PCM interface
  - I2C interface
  - Status indication
  - Power control interface

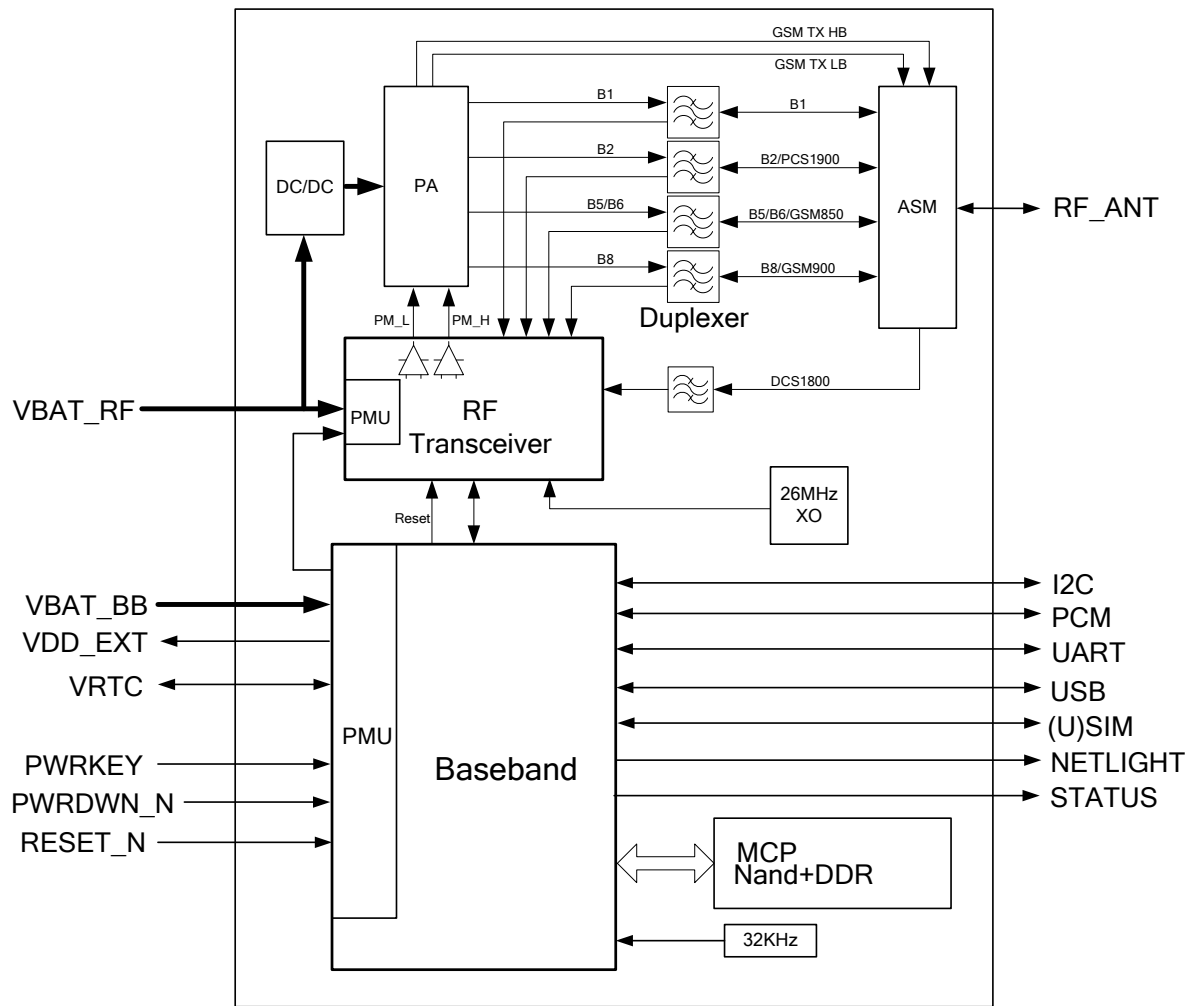


Figure 1: Functional Diagram

## 2.4. Evaluation Board

In order to help customers develop applications conveniently with UG96, Quectel supplies an evaluation board (UMTS&LTE-EVB), RS-232 to USB cable, USB data cable, power adapter, earphone, antenna and other peripherals to control or test the module. For details, please refer to **document [2]**.

# 3 Application Interfaces

## 3.1. General Description

UG96 is equipped with 62-pin 1.1mm pitch SMT pads plus 40-pin ground/reserved pads that can be connected to customers' cellular application platforms. Sub-interfaces included in these pads are described in detail in the following chapters:

- Power supply
- RTC interface
- UART interface
- (U)SIM interface
- USB interface
- PCM and I2C interfaces
- Status indication



## 3.2. Pin Assignment

The following figure shows the pin assignment of UG96 module.

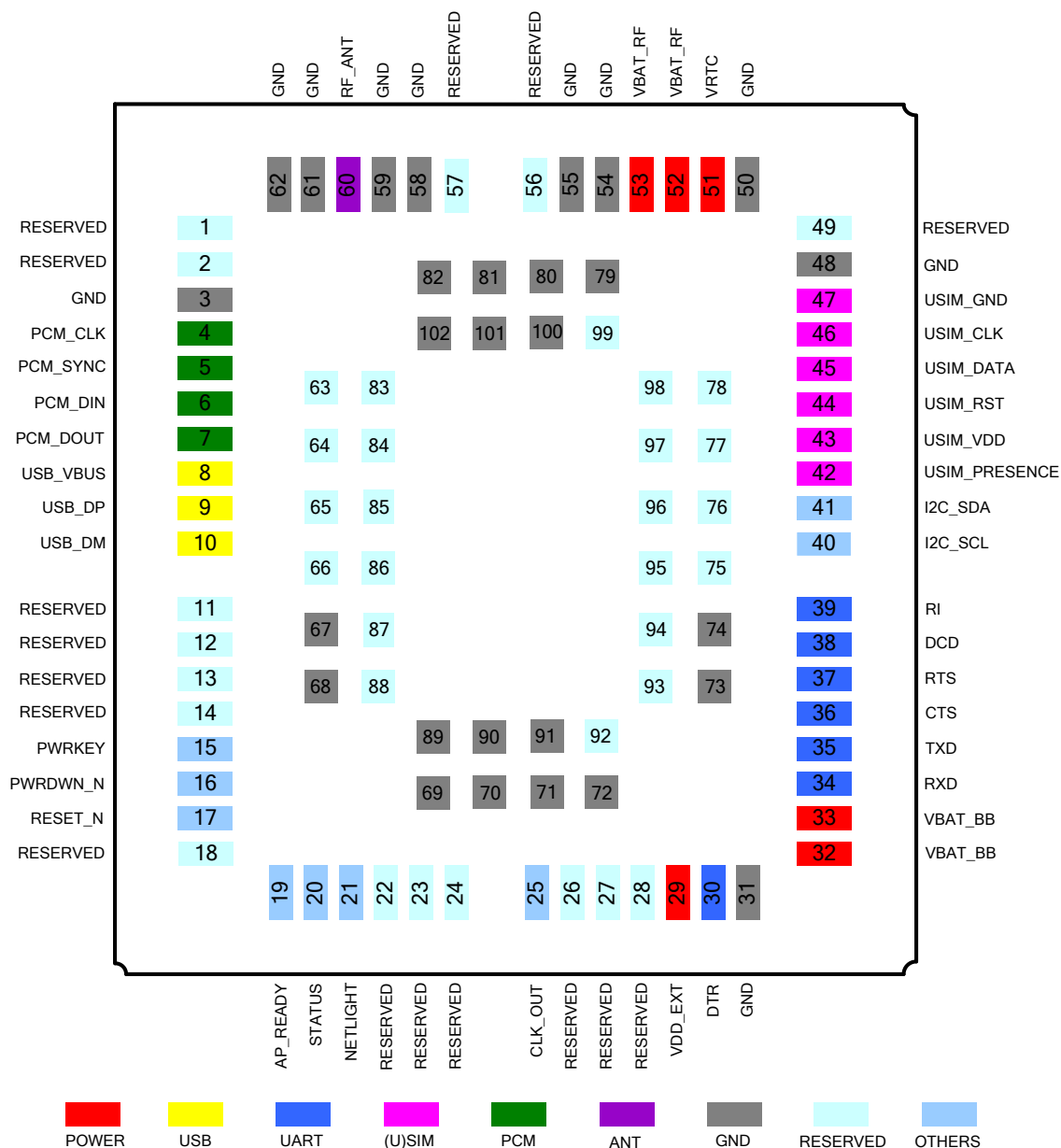


Figure 2: Pin Assignment (Top View)

### NOTES

1. Keep all RESERVED and unused pins unconnected.
2. GND pads should be connected to ground in the design.

### 3.3. Pin Description

The following tables show the pin definition of UG96 module.

**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_BB	32, 33	PI	Power supply for module's baseband part	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	It must be able to provide sufficient current in a transmitting burst which typically rises to 2.0A.
VBAT_RF	52, 53	PI	Power supply for module's RF part	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	
VRTC	51	PI/ PO	Power supply for internal RTC circuit	Vnorm=1.8V when VBAT≥3.3V VI=1V~1.9V at IINmax=2uA when VBAT is not applied.	If unused, keep it open.
VDD_EXT	29	PO	Provide 1.8V for external circuit	Vnorm=1.8V Iomax=20mA	Power supply for external GPIO's pull up circuits.

If unused, keep it open.

GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67~74, 79~82, 89~91, 100~102	Ground
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#### Turn On/Off

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
PWRKEY	15	DI	Turn on the module	$R_{PU} \approx 200K\Omega$ $V_{IHmax} = 2.1V$ $V_{IHmin} = 1.3V$ $V_{ILmax} = 0.5V$	Pull-up to VRTC internally. Active low.
PWRDWN_N	16	DI	Turn off the module	$R_{PU} \approx 4.7K\Omega$ $V_{IHmax} = 2.1V$ $V_{IHmin} = 1.3V$ $V_{ILmax} = 0.5V$	Pull-up to VRTC internally. Active low. If unused, keep it open.
RESET_N	17	DI	Reset signal of the module	$R_{PU} \approx 200K\Omega$ $V_{IHmax} = 2.1V$ $V_{IHmin} = 1.3V$ $V_{ILmax} = 0.5V$	Pull-up to VRTC internally. Active low. If unused, keep it open.

#### Status Indication

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
STATUS	20	DO	Indicate the module operating status	$V_{OHmin} = 1.3V$ $V_{OLmax} = 0.5V$	1.8V power domain. If unused, keep it open.
NETLIGHT	21	DO	Indicate the module network status	$V_{OHmin} = 1.3V$ $V_{OLmax} = 0.5V$	1.8V power domain. If unused, keep it open.

#### USB Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
USB_VBUS	8	PI	USB detection	$V_{max} = 5.25V$ $V_{min} = 2.5V$ $V_{norm} = 5.0V$	
USB_DP	9	IO	USB differential data	Compliant with USB	Require differential

			bus (+)	2.0 standard specification.	impedance of 90Ω.
USB_DM	10	IO	USB differential data bus (-)	Compliant with USB 2.0 standard specification.	Require differential impedance of 90Ω.

#### (U)SIM Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
USIM_GND	47		Specified ground for (U)SIM card		
USIM_VDD	43	PO	Power supply for (U)SIM card	For 1.8V (U)SIM: V <sub>max</sub> =1.85V V <sub>min</sub> =1.75V  For 3.0V (U)SIM: V <sub>max</sub> =2.9V V <sub>min</sub> =2.8V	Either 1.8V or 3.0V is supported by the module automatically.
USIM_DATA	45	IO	Data signal of (U)SIM card	For 1.8V (U)SIM: V <sub>ILmax</sub> =0.35V V <sub>IHmin</sub> =1.25V V <sub>OLmax</sub> =0.25V V <sub>OHmin</sub> =1.25V  For 3.0V (U)SIM: V <sub>ILmax</sub> =0.5V V <sub>IHmin</sub> =2.05V V <sub>OLmax</sub> =0.25V V <sub>OHmin</sub> =2.05V	Pull-up to USIM_VDD with 4.7K resistor internally.
USIM_CLK	46	DO	Clock signal of (U)SIM card	For 1.8V (U)SIM: V <sub>OLmax</sub> =0.25V V <sub>OHmin</sub> =1.25V  For 3.0V (U)SIM: V <sub>OLmax</sub> =0.25V V <sub>OHmin</sub> =2.05V	
USIM_RST	44	DO	Reset signal of (U)SIM card	For 1.8V (U)SIM: V <sub>OLmax</sub> =0.25V V <sub>OHmin</sub> =1.25V  For 3.0V (U)SIM: V <sub>OLmax</sub> =0.3V V <sub>OHmin</sub> =2.05V	

USIM_	42	DI	(U)SIM card insertion detection	$V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. External pull-up resistor is required.
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#### Main UART Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RI	39	DO	Ring indicator	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. If unused, keep it open.
DCD	38	DO	Data carrier detection	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. If unused, keep it open.
CTS	36	DO	Clear to send	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. If unused, keep it open.
RTS	37	DI	Request to send	$V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. If unused, keep it open.
DTR	30	DI	Data terminal ready. Sleep mode control.	$V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. If unused, keep it open.
TXD	35	DO	Transmit data	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. If unused, keep it open.
RXD	34	DI	Receive data	$V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. If unused, keep it open.

#### RF Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RF_ANT	60	IO	RF antenna	50Ω impedance	

#### PCM Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
PCM_IN	6	DI	PCM data input	$V_{ILmin}=-0.3V$ $V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. If unused, keep it open.
PCM_OUT	7	DO	PCM data output	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. If unused, keep it open.

PCM_SYNC	5	DO	PCM data frame synchronization signal	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. In master mode, it is an output signal. If unused, keep it open.
PCM_CLK	4	DO	PCM data bit clock	$V_{OLmax}=0.25V$ $V_{OHmin}=1.55V$	1.8V power domain. In master mode, it's an output signal. If unused, keep it open.

#### I2C Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
I2C_SCL	40	OD	I2C serial clock. Used for external codec		1.8V power domain. External pull-up resistor is required. If unused, keep it open.
I2C_SDA	41	OD	I2C serial data. Used for external codec		1.8V power domain. External pull-up resistor is required. If unused, keep it open.

#### Other Pins

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
AP_READY*	19	DI	Application processor sleep state detection	$V_{ILmin}=-0.3V$ $V_{ILmax}=0.35V$ $V_{IHmin}=1.3V$ $V_{IHmax}=1.85V$	1.8V power domain. If unused, keep it open.
CLK_OUT	25	DO	Clock output		Provide a digital clock output for an external audio codec. If unused, keep it open.

#### RESERVED Pins

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESERVED	1, 2, 11~14, 18, 22~24,		Reserved		Keep these pins unconnected.

26~28,  
49,  
56, 57,  
63~66,  
75~78,  
83~88,  
92~99

**NOTE**

“(★)” means under development.

### 3.4. Operating Modes

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

**Table 5: Overview of Operating Modes**

Mode	Details	
Normal Operation	GSM Idle	The module has registered on the GSM network and is ready to send and receive data.
	GSM Talk/Data	GSM connection is ongoing. In this mode, the power consumption is decided by the configuration of power control level (PCL), dynamic DTX control and the working RF band.
	GPRS Idle	The module is ready for GPRS data transfer, but no data transfer is going on. In this case, power consumption is decided by network setting and GPRS configuration.
	GPRS Data	There is GPRS data (PPP, TCP or UDP) in transfer. In this mode, power consumption is decided by the PCL, working RF band and GPRS multi-slot configuration.
	EDGE Idle	The module is ready for data transfer in EDGE mode, but no data is currently sent or received. In this case, power consumption is decided by network settings and EDGE configuration.
	EDGE Data	There is EDGE data (PPP, TCP or UDP) in transfer.
	UMTS Idle	The module has registered on the UMTS network and is ready to send and receive data.
	UMTS Talk/Data	UMTS connection is ongoing. In this mode, the power consumption is decided by network setting (e.g. TPC pattern) and

	data transfer rate.				
	<table> <tr> <td>HSPA Idle</td><td>The module has registered on the HSPA network and is ready to send and receive data.</td></tr> <tr> <td>HSPA Data</td><td>HSPA data transfer is ongoing. In this mode, the power consumption is decided by network setting (e.g. TPC pattern) and data transfer rate.</td></tr> </table>	HSPA Idle	The module has registered on the HSPA network and is ready to send and receive data.	HSPA Data	HSPA data transfer is ongoing. In this mode, the power consumption is decided by network setting (e.g. TPC pattern) and data transfer rate.
HSPA Idle	The module has registered on the HSPA network and is ready to send and receive data.				
HSPA Data	HSPA data transfer is ongoing. In this mode, the power consumption is decided by network setting (e.g. TPC pattern) and data transfer rate.				
Minimum Functionality Mode	<b>AT+CFUN</b> command can set the module entering into a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be invalid.				
Sleep Mode	In this mode, the current consumption of the module will be reduced to the minimal level. During this mode, the module can still receive paging message, SMS and voice call from the network normally.				
Power Down Mode	In this mode, the power management unit shuts down the power supply for the baseband part and RF part. Only the power supply for RTC remains. Software is not active. The serial interface is not accessible. Operating voltage (connected to VBAT_RF and VBAT_BB) remains applied.				

## 3.5. Power Saving

### 3.5.1. Sleep Mode

UG96 is able to reduce its current consumption to a minimum value during the sleep mode. The following sub-chapters describe power saving procedures of UG96.

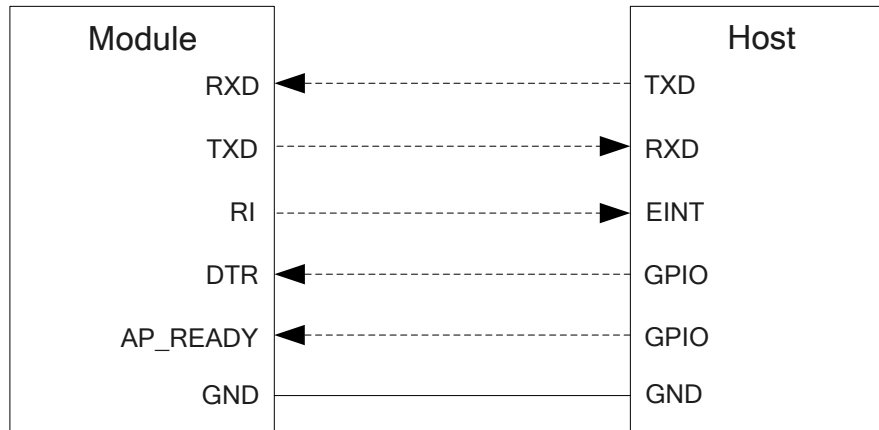
#### 3.5.1.1. UART Application

If the host communicates with module via UART interface, the following preconditions must be met to let the module enter into sleep mode.

- Execute **AT+QCFG="uart/power",0,0** to set UART into auto on/off mode.
- Execute **AT+QSCLK=1** to enable the sleep mode.
- Drive DTR to high level.

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





**Figure 3: Sleep Mode Application via UART**

The RI of module is used to wake up the host and AP\_READY\* will detect the sleep state of host (can be configured to high level or low level detection). Customers should pay attention to the level match shown in dotted line between module and host. Drive DTR pin to low level to wake up the module.

In sleep mode for UART application, the UART port is not accessible.

**NOTE**

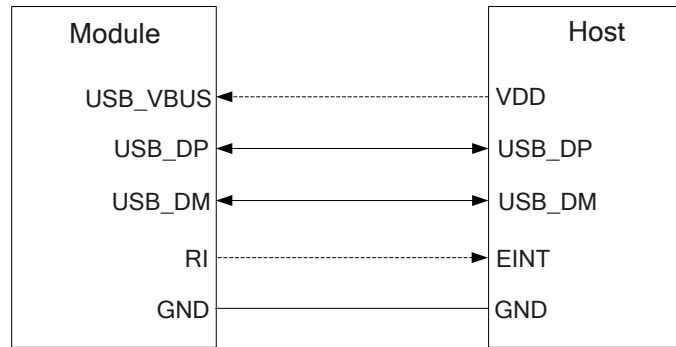
“\*” means under development.

### 3.5.1.2. USB Application with Suspend Function

If the host communicates with module via USB interface and supports USB suspend function, the following preconditions must be met to let the module enter into sleep mode.

- Execute **AT+QCFG="uart/power",0,0** to set UART into auto on/off mode.
- Execute **AT+QSCLK=1** to enable the sleep mode.
- The host's USB bus, which is connected with the module's USB interface, enters into suspended state.

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



**Figure 4: USB Application with Suspend Function**

When the host's USB bus returns to resume state, the module will be woken up.

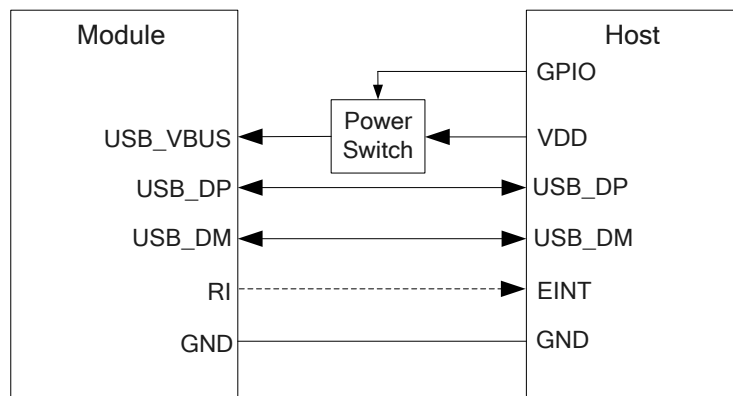
### 3.5.1.3. USB Application without Suspend Function

If the host communicates with module via USB interface, and does not support USB suspend function, USB\_VBUS should be disconnected with an external control circuit to let the module enter into sleep mode.

- Execute **AT+QCFG="uart/power",0,0** to set UART into auto on/off mode.
- Execute **AT+QSCLK=1** to enable the sleep mode.
- Disconnect USB\_VBUS.

Supplying power to USB\_VBUS will wake up the module.

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



**Figure 5: Sleep Mode Application without Suspend Function**

## NOTES

In sleep mode, the module can still receive paging message, SMS, voice call and TCP/UDP data from the network normally.

### 3.5.2. Minimum Functionality Mode

Minimum functionality mode reduces the functionality of the module to minimum level, thus minimizes the current consumption at the same time. This mode can be set as below:

Command **AT+CFUN** provides the choice of the functionality levels: <fun>=0, 1, 4.

- **AT+CFUN=0**: Minimum functionality, RF part and (U)SIM card will be closed.
- **AT+CFUN=1**: Full functionality (by default).
- **AT+CFUN=4**: Disable RF function (airplane mode). All AT commands related to RF function are not accessible.

For detailed information about command **AT+CFUN**, please refer to **document [1]**.

## 3.6. Power Supply

### 3.6.1. Power Supply Pins

UG96 provides four VBAT pins for connection with the external power supply. There are two separate voltage domains for VBAT.

- Two VBAT\_RF pins for module RF part.
- Two VBAT\_BB pins for module baseband part.

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

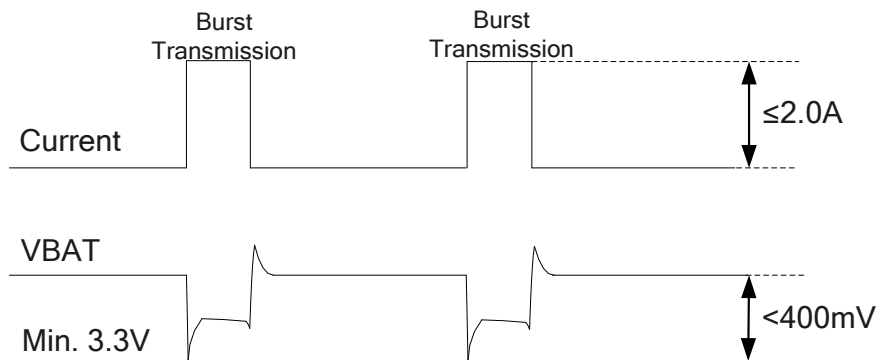
**Table 6: VBAT and GND Pins**

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT_RF	52, 53	Power supply for module's RF part.	3.3	3.8	4.3	V
VBAT_BB	32, 33	Power supply for module's baseband part.	3.3	3.8	4.3	V
GND	3, 31, 48, 50 54, 55, 58,	Ground	-	-	-	-

59, 61, 62,  
67~74,  
79~82,  
89~91,  
100~102

### 3.6.2. Decrease Voltage Drop

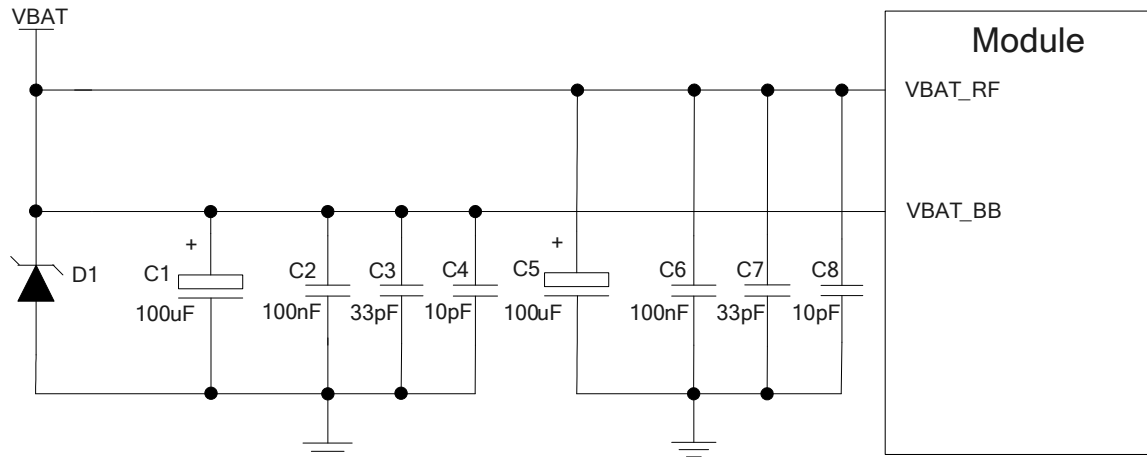
The power supply range of the module is 3.3V~4.3V. Please make sure that the input voltage will never drop below 3.3V. If the voltage drops to below 3.3V, the module will be turned off automatically. The following figure shows the voltage drop during burst transmission in 2G network. The voltage drop will be less in 3G and 4G networks.



**Figure 6: Voltage Drop during Burst Transmission**

To decrease voltage drop, a bypass capacitor of about 100μF with low ESR (ESR=0.7Ω) should be used, and a multi-layer ceramic chip (MLCC) capacitor array should also be reserved due to its ultra-low ESR. It is recommended to use three ceramic capacitors (100nF, 33pF, 10pF) for composing the MLCC array, and place these capacitors close to VBAT\_BB/VBAT\_RF pins. The main power supply from an external application has to be a single voltage source and can be expanded to two sub paths with star structure. The width of VBAT\_BB trace should be no less than 1mm, and the width of VBAT\_RF trace should be no less than 2mm. In principle, the longer the VBAT trace is, the wider it will be.

In addition, in order to get a stable power source, it is suggested that a zener diode whose dissipation power is more than 0.5W should be used. The following figure shows the star structure of the power supply.

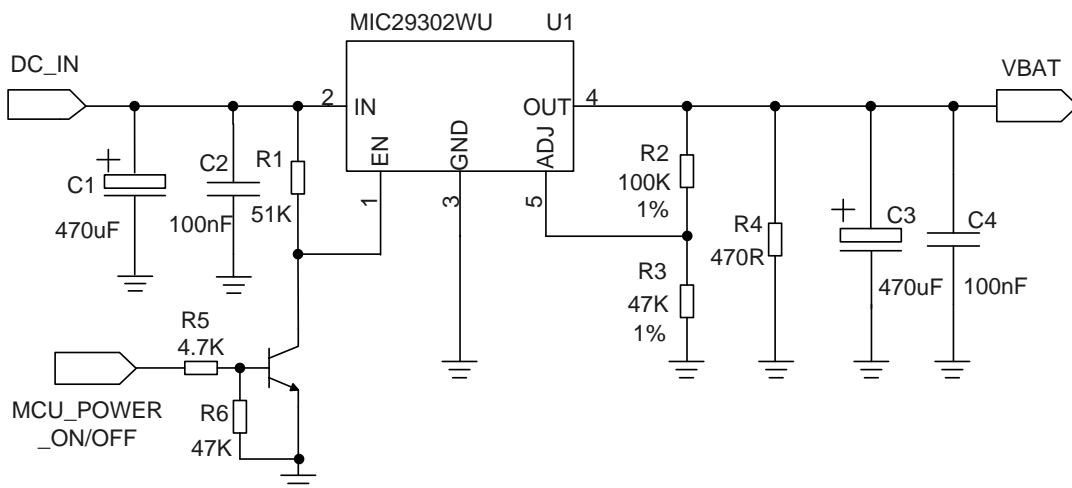


**Figure 7: Star Structure of the Power Supply**

### 3.6.3. Reference Design for Power Supply

The power design for the module is very important, as the performance of module largely depends on the power source. The power supply should be able to provide sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be used to supply power for module. If there is a big voltage difference between the input source and the desired output (VBAT), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5V input power source. The typical output of the power supply is about 3.8V and the maximum load current is 3A.



**Figure 8: Reference Circuit of Power Supply**

#### NOTE

It is suggested that customers should switch off power supply for module in abnormal state, and then switch on power to restart module.

### 3.6.4. Monitor the Power Supply

Command **AT+CBC** can be used to monitor the VBAT\_BB voltage value displayed in millivolt. For more details, please refer to **document [1]**.

## 3.7. Turn on and off Scenarios

### 3.7.1. Turn on Module Using the PWRKEY

The following table shows the pin definition of PWRKEY.

Table 7: Pin Definition of PWRKEY

Pin Name	Pin No.	Description	DC Characteristics	Comment
PWRKEY	15	Turn on the module	$V_{IHmax}=2.1V$ $V_{IHmin}=1.3V$ $V_{ILmax}=0.5V$	Pull-up to VRTC internally with 200K $\Omega$ resistor.

When UG96 is in power off mode, it can be turned on to normal mode by driving the PWRKEY pin to a low level for at least 100ms. It is recommended to use an open drain/collector driver to control the PWRKEY. After STATUS pin outputting a high level, PWRKEY pin can be released. A simple reference circuit is illustrated in the following figure.

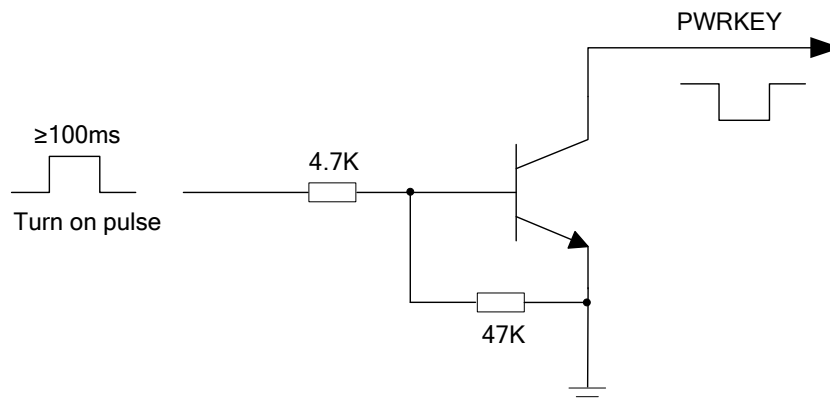
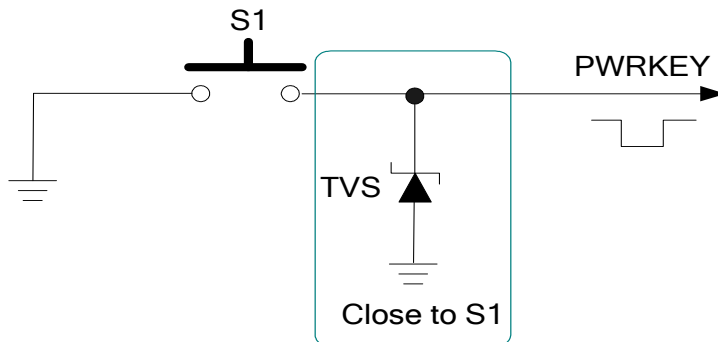


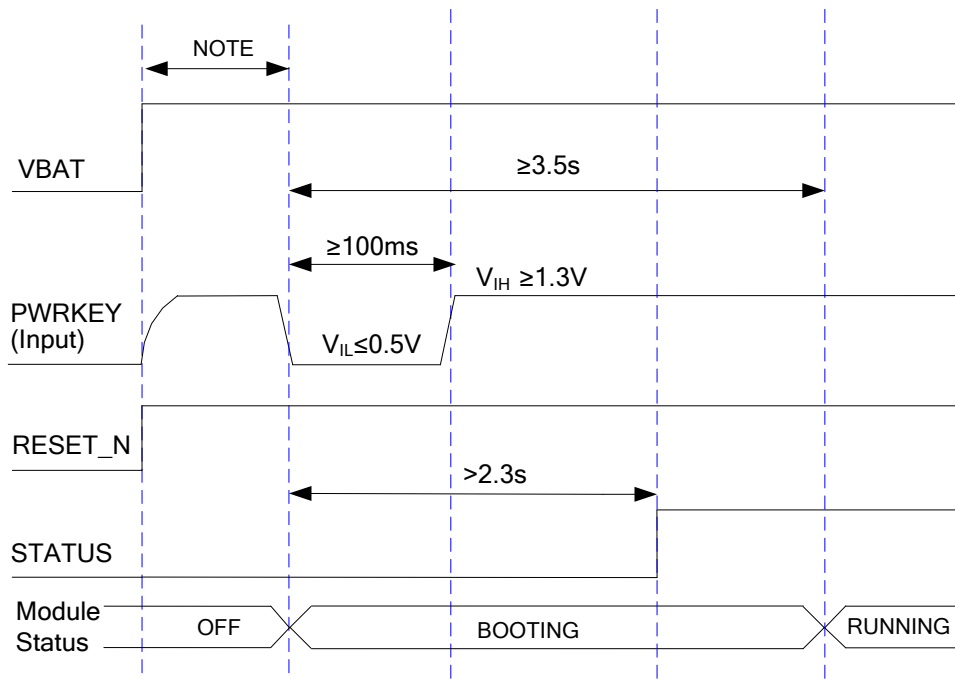
Figure 9: Turn on the Module Using Driving Circuit

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



**Figure 10: Turn on the Module Using Keystroke**

The turn on scenarios is illustrated as the following figure.



**Figure 11: Timing of Turning on Module**

**NOTE**

Please make sure that VBAT is stable before pulling down PWRKEY pin. The time between them is no less than 30ms. It is not suggested to pull down PWRKEY pin all the time.

### 3.7.2. Turn off Module

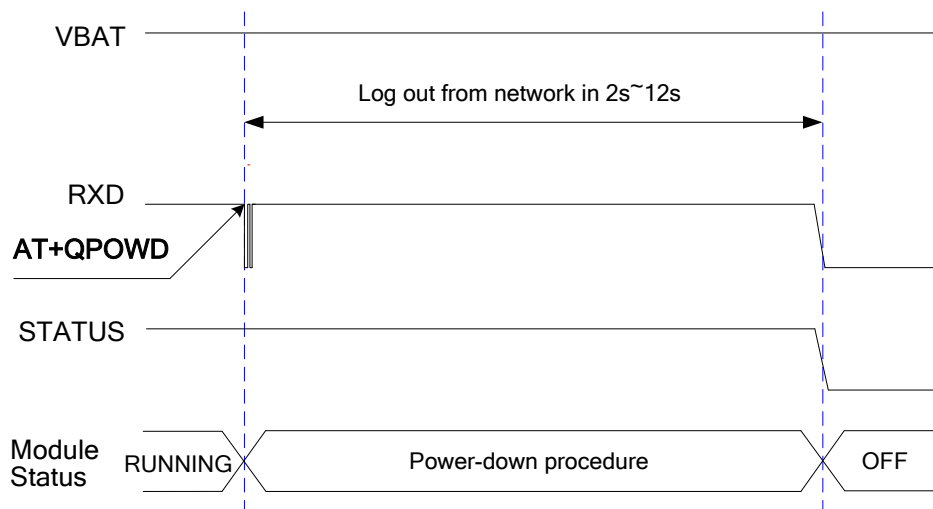
Any of the following methods can be used to turn off the module:

- Normal power down procedure: Turn off the module using command **AT+QPOWD**.
- Emergency power down procedure: Turn off the module using the PWRDWN\_N pin.
- Automatic shutdown: Turn off the module automatically if under-voltage or over-voltage is detected.

#### 3.7.2.1. Turn off Module Using AT Command

There are several different ways to turn off the module. It is recommended to turn off the module by command **AT+QPOWD**. It is a safe way to turn off the module. This command will let the module log off from the network and allow the firmware to save important data before completely disconnecting the power supply.

The power down scenario is illustrated as the following figure.



**Figure 12: Timing of Turning off through AT Command**

During power down procedure, module will log off from network and save important data. After logging off, module sends out “OK”, then sends out “POWERED DOWN” and shuts down the internal power supply. The power on VBAT pins is not allowed to be turned off before the URC “POWERED DOWN” is outputted to avoid data loss. If logging off is not done within 40s, module will shut down internal power supply forcibly.

After that moment, module enters into the power down mode, and no other AT commands can be executed except that only the RTC is still active. Please refer to **document [1]** for details about the command **AT+QPOWD**.



### 3.7.2.2. Emergency Shutdown

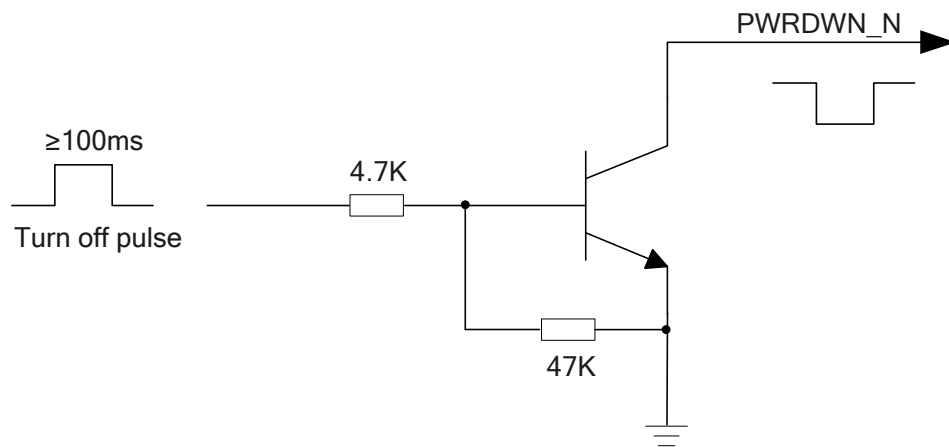
The module can be shut down by the pin PWRDWN\_N. It should only be used under emergency situation.

The following table shows the pin definition of PWRDWN\_N.

**Table 8: Pin Definition of PWRDWN\_N**

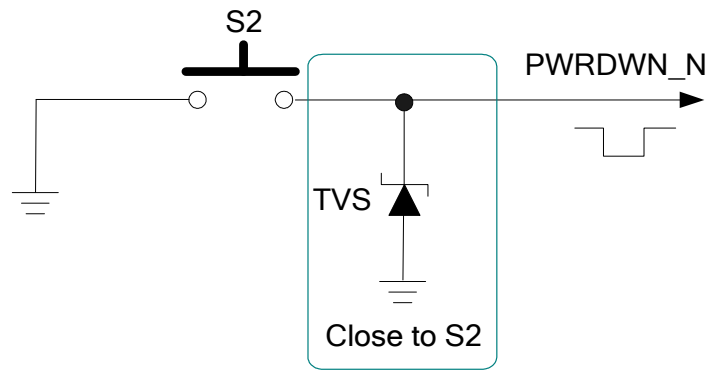
Pin Name	Pin No.	Description	DC Characteristics	Comment
PWRDWN_N	16	Turn off the module	$V_{IHmax}=2.1V$ $V_{IHmin}=1.3V$ $V_{ILmax}=0.5V$	Pull-up to VRTC internally with 4.7K $\Omega$ resistor.

Drive the PWRDWN\_N to a low level voltage for at least 100ms, the module will execute power down procedure after PWRDWN\_N is released. It is recommended to use an open drain/collector driver to control the PWRDWN\_N. The level of STATUS pin is low after UG96 is turned off. A simple reference circuit is illustrated in the following figure.



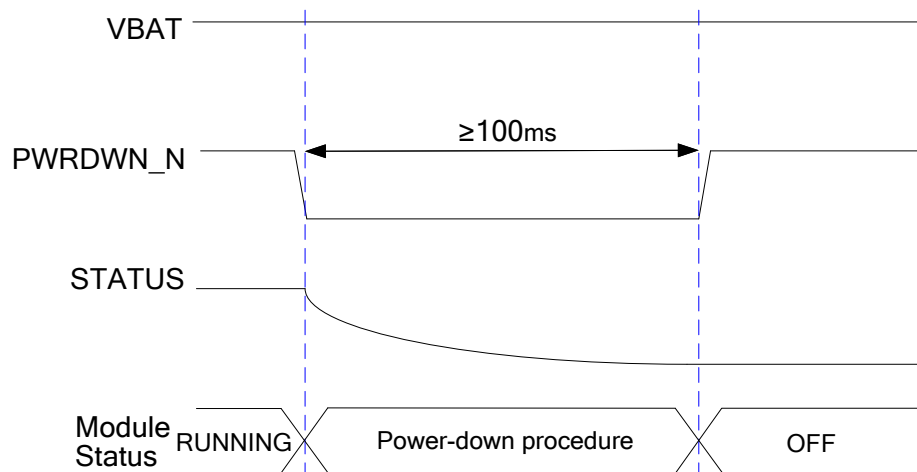
**Figure 13: Turn off the Module Using Driving Circuit**

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



**Figure 14: Turn off the Module Using Keystroke**

The emergency shutdown scenario is illustrated as the following figure.



**Figure 15: Timing of Emergency Shutdown**

**NOTE**

PWRDWN\_N can only be used when turning off the module by command **AT+QPOWD** or the RESET\_N pin fails.

### 3.7.2.3. Automatic Shutdown

The module will constantly monitor the voltage applied on the VBAT, if the voltage  $\leq 3.5V$ , the following URC will be presented:

**+QIND: "vbatt",-1**

If the voltage  $\geq 4.21V$ , the following URC will be presented:

**+QIND: "vbatt",1**

The uncritical voltage is 3.3V~4.3V, If the voltage  $> 4.3V$  or  $< 3.3V$ , the module would automatically shut down itself.

If the voltage  $< 3.3V$ , the following URC will be presented:

**+QIND: "vbatt",-2**

If the voltage  $> 4.3V$ , the following URC will be presented:

**+QIND: "vbatt",2**

#### NOTE

The value of voltage threshold can be revised by AT command. Please refer to **document [1]** for details.

## 3.8. Reset the Module

The RESET\_N can be used to reset the module. The module can be reset by driving the RESET\_N to a low level voltage for more than 100ms and then releasing.

**Table 9: Pin Definition of RESET\_N**

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET_N	17	Reset signal of the module	$V_{IHmax}=2.1V$ $V_{IHmin}=1.3V$ $V_{ILmax}=0.5V$	Pull-up to VRTC internally with 200K $\Omega$ resistor. Active low.

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

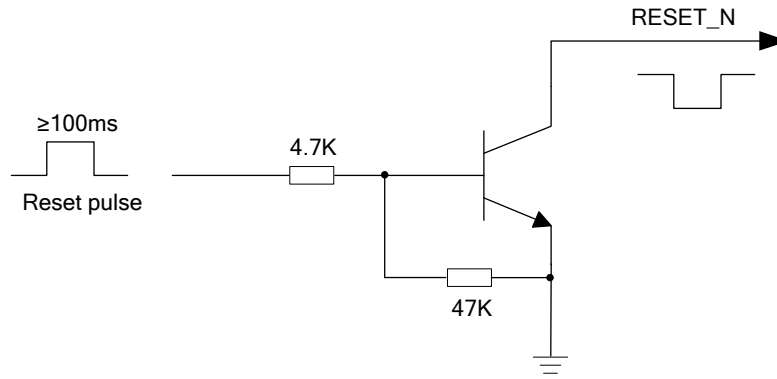


Figure 16: Reference Circuit of RESET\_N by Using Driving Circuit

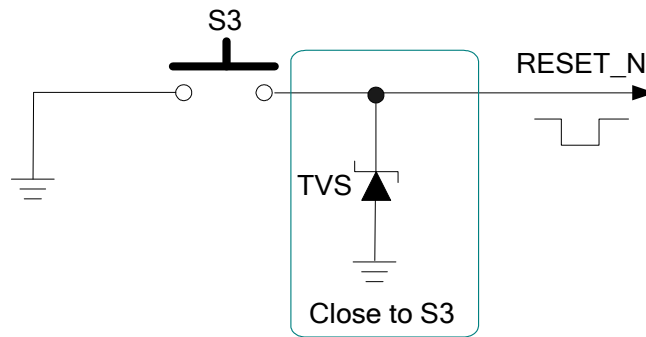


Figure 17: Reference Circuit of RESET\_N by Using Button

The reset scenario is illustrated as the following figure.

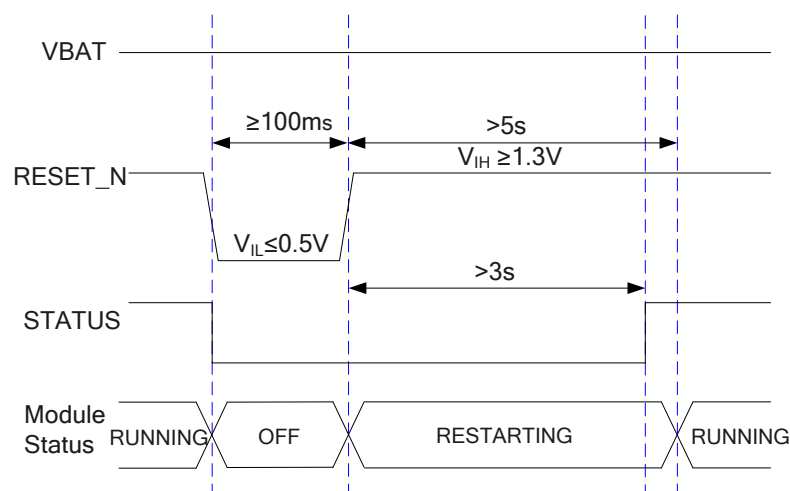


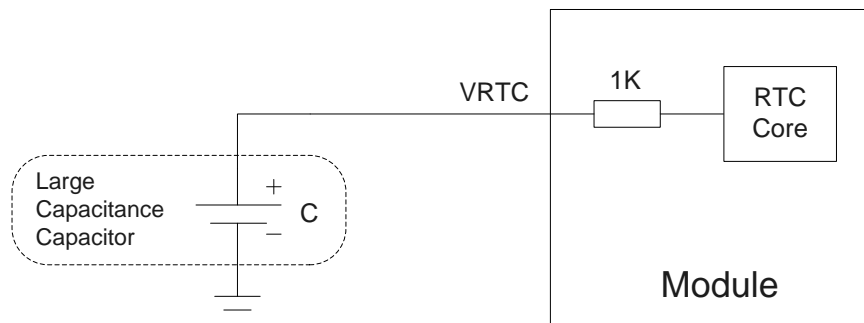
Figure 18: Timing of Resetting Module

### 3.9. RTC Interface

The RTC (Real Time Clock) can be powered by an external capacitor through the pin VRTC when the module is powered down and there is no power supply for the VBAT. If the voltage supply at VBAT is disconnected, the RTC can be powered by the capacitor. The capacitance determines the duration of buffering when no voltage is applied to UG96.

The capacitor is charged from the internal LDO of UG96 when there is power supply for the VBAT. A serial 1KΩ resistor has been placed on the application inside the module. It limits the input current of the capacitor.

The following figure shows the reference circuit for VRTC backup.



**Figure 19: RTC Supply from Capacitor**

In order to evaluate the capacitance of capacitor according to the backup time, the following parameters should be considered:

- VRTC - The starting voltage of the capacitor. (Volt)
- VRTC<sub>MIN</sub> - The minimum voltage acceptable for the RTC circuit. (Volt)
- I - The current consumption of the RTC circuitry when VBAT=0. (Ampere)
- B<sub>Time</sub> - Backup Time. (Second)
- C - The backup capacitance. (Farad)

When the power is off and only VRTC is running, the way of calculating the backup capacitor is as follows:

$$C = B_{Time} * I / (V_{RTC} - V_{RTC_{MIN}})$$

For example, when the capacitor is 1000uF:

- VRTC=1.8V
- VRTC<sub>MIN</sub>=1.0V
- I=2uA
- C=1000uF

The backup time is about 400s.

### 3.10. UART Interface

The module provides 7-wire UART interface.

The UART interface supports 300bps, 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps and 921600bps baud rates, and the default is auto-baud rate 4800bps~115200bps. This interface can be used for data transmission, AT command communication and firmware upgrade.

The module is designed as DCE (Data Communication Equipment). The following table shows the pin definition of UART interface.

**Table 10: Pin Definition of Main UART Interface**

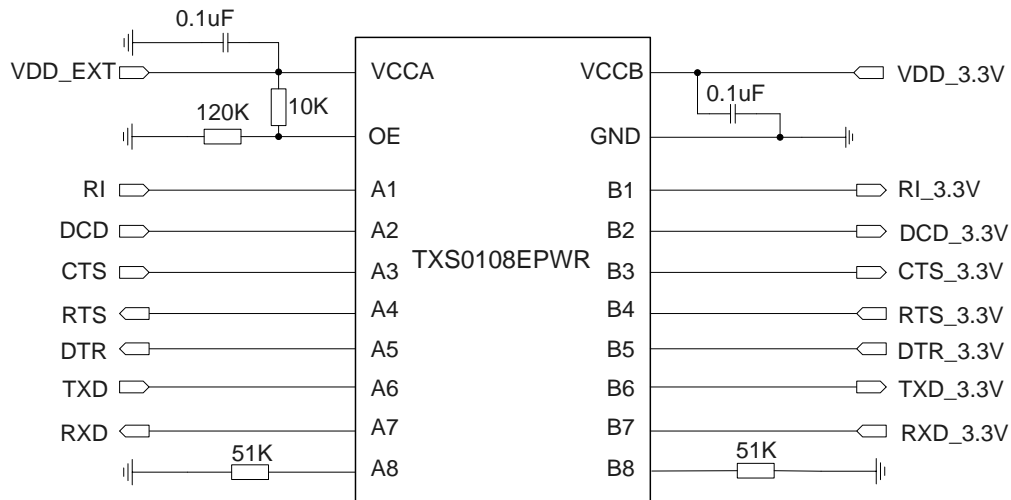
Pin Name	Pin No.	I/O	Description	Comment
DTR	30	DI	Data terminal ready. Sleep mode control.	1.8V power domain
RXD	34	DI	Receive data	1.8V power domain
TXD	35	DO	Transmit data	1.8V power domain
CTS	36	DO	Clear to send	1.8V power domain
RTS	37	DI	Request to send	1.8V power domain
DCD	38	DO	Data carrier detection	1.8V power domain
RI	39	DO	Ring indicator	1.8V power domain

The logic levels are described in the following table.

**Table 11: Logic Levels of Digital I/O**

Parameter	Min.	Max.	Unit
V <sub>IL</sub>	-0.3	0.35	V
V <sub>IH</sub>	1.3	1.85	V
V <sub>OL</sub>	0	0.25	V
V <sub>OH</sub>	1.55	1.8	V

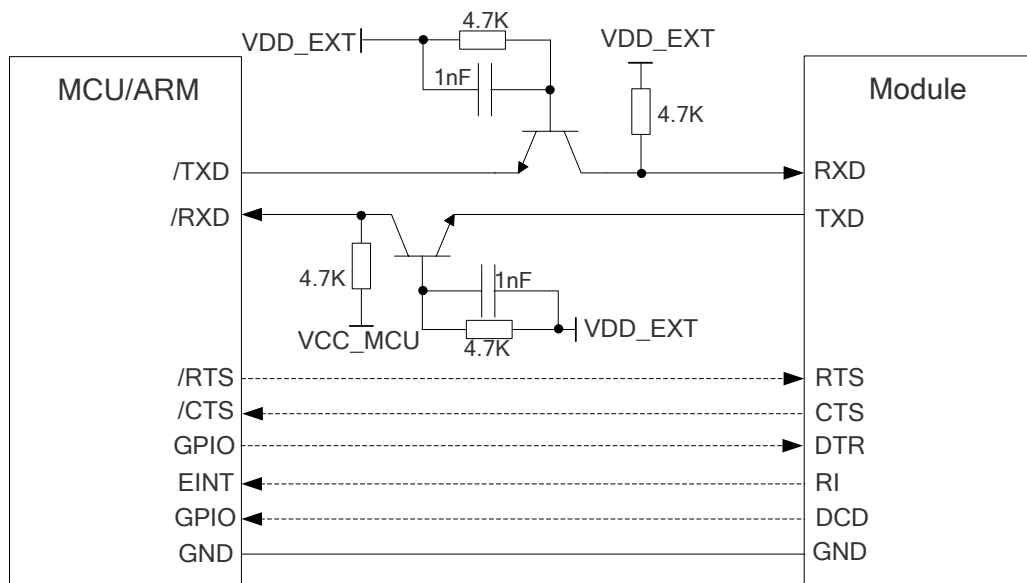
UG96 provides one 1.8V UART interface. A level translator should be used if customers' application is equipped with a 3.3V UART interface, and TXS0108EPWR provided by *Texas Instruments* is recommended. The following figure shows a reference design.



**Figure 20: Reference Circuit of Logic Level Translator**

Please visit <http://www.ti.com> for more information.

Another example with transistor translation circuit is shown as below. The circuit design of dotted line section can refer to the design of solid line section. Please pay attention to the direction of connection. The transistor translation circuit supports a maximum data rate of 0.5Mbps.



**Figure 21: Reference Circuit with Transistor Circuit**

The following figure is an example of connection between UG96 and PC. A voltage level translator and a RS-232 level translator chip must be inserted between module and PC, since the UART interface does not support the RS-232 level, while supports the 1.8V CMOS level only.

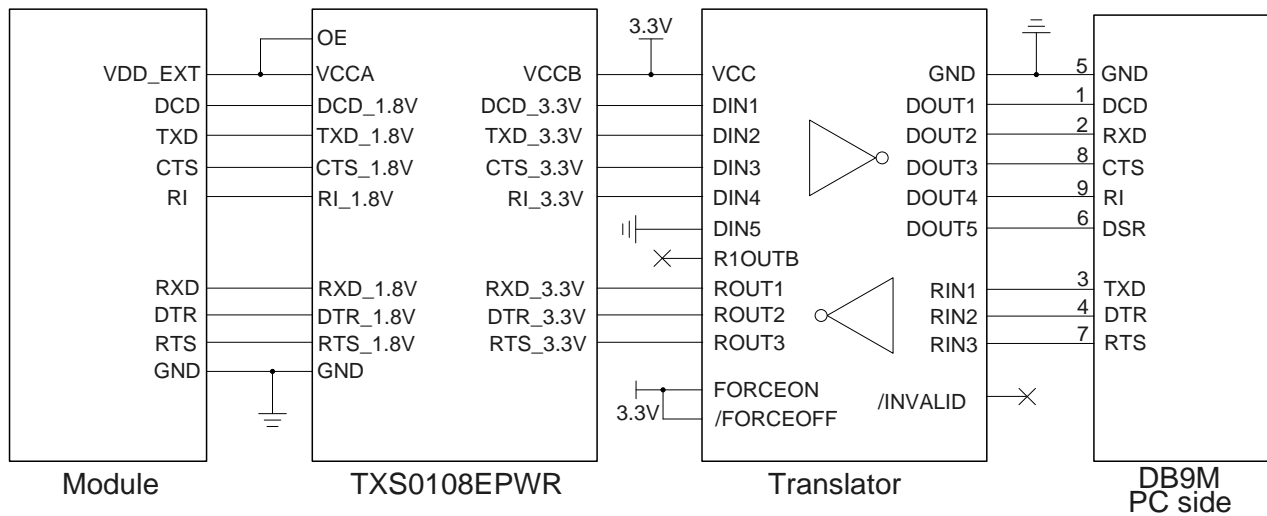


Figure 22: RS232 Level Match Circuit

#### NOTES

1. The module disables the hardware flow control by default. When hardware flow control is required, RTS and CTS should be connected to the host. Command **AT+IFC=2,2** is used to enable hardware flow control and **AT+IFC=0,0** is used to disable the hardware flow control. For more details, please refer to **document [1]**.
2. Rising edge on DTR will let the module exit from the data mode by default, and it can be disabled by AT commands. Please refer to **document [1]** for details.
3. DCD is used as data mode indication. Please refer to **document [1]** for details.
4. It is suggested that USB\_DP, USB\_DM and USB\_VBUS pins should be set as test points and then be placed on DTE for debugging.



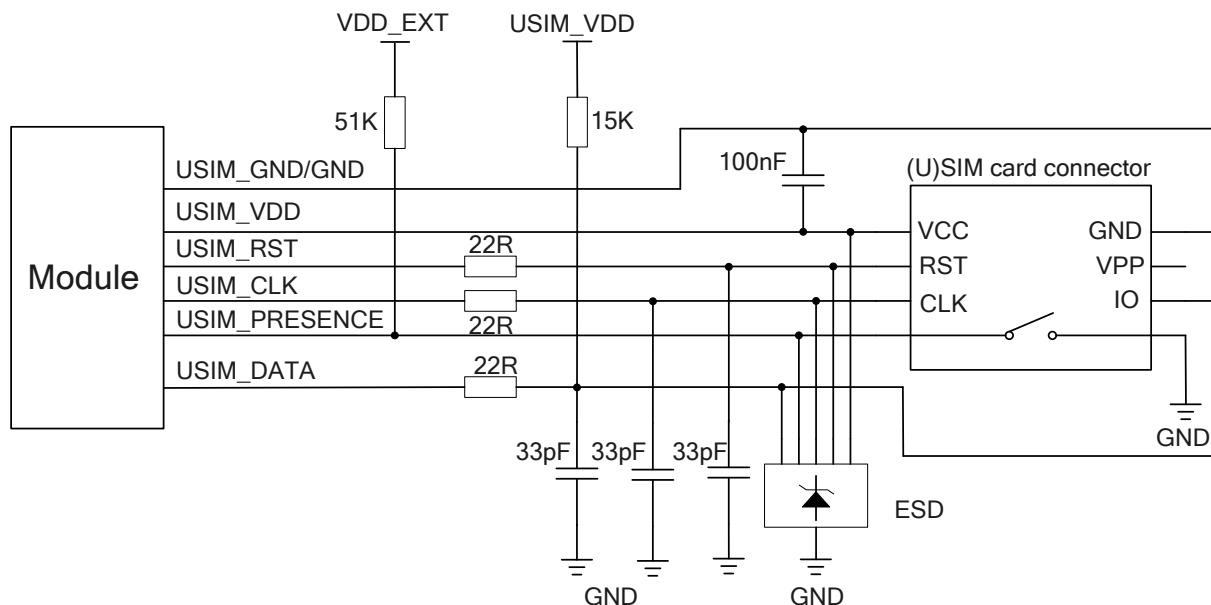
### 3.11. (U)SIM Interface

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (U)SIM cards are supported.

**Table 12: Pin Definition of (U)SIM Interface**

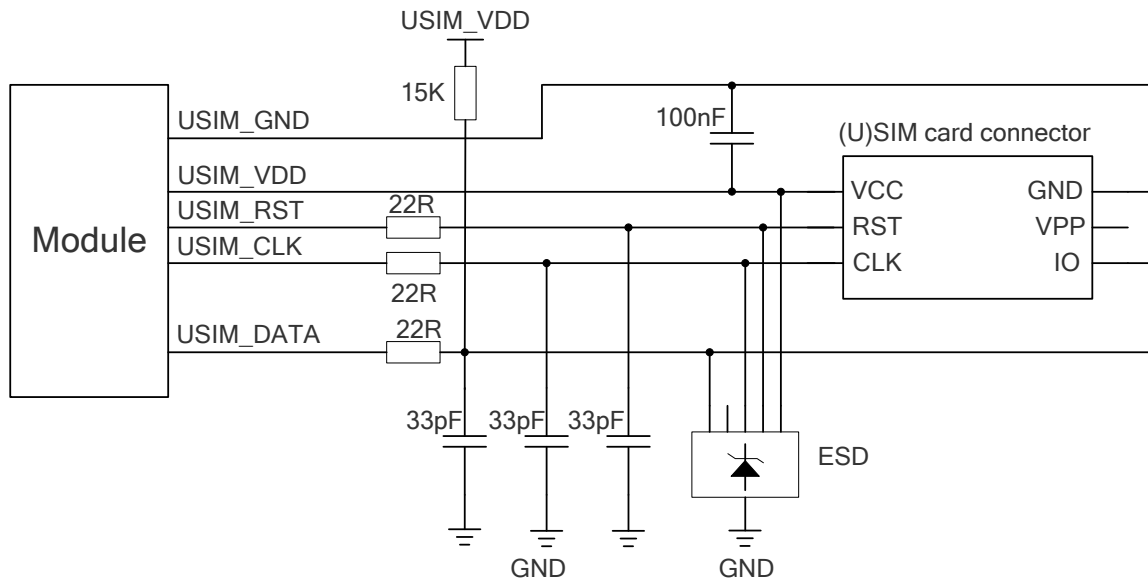
Pin Name	Pin No.	I/O	Description	Comment
USIM_PRESENCE	42	DI	(U)SIM card insertion detection	1.8V power domain.
USIM_VDD	43	PO	Power supply for (U)SIM card	Either 1.8V or 3.0V is supported by the module automatically.
USIM_RST	44	DO	Reset signal of (U)SIM card	
USIM_DATA	45	IO	Data signal of (U)SIM card	Pull-up to USIM_VDD with 4.7k resistor internally.
USIM_CLK	46	DO	Clock signal of (U)SIM card	
USIM_GND	47		Specified ground for (U)SIM card	

UG96 supports (U)SIM card hot-plug via the USIM\_PRESENCE pin. The following figure shows a reference design for (U)SIM interface with an 8-pin (U)SIM card connector.



**Figure 23: Reference Circuit of (U)SIM Interface with an 8-Pin (U)SIM Card Connector**

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



**Figure 24: Reference Circuit of (U)SIM Interface with a 6-Pin (U)SIM Card Connector**

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

- Keep placement of (U)SIM card connector as close to the module as possible. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signal away from RF and VBAT traces.
- Assure the ground between the module and the (U)SIM card connector short and wide. Keep the trace width of ground no less than 0.5mm to maintain the same electric potential. Make sure the decouple capacitor between USIM\_VDD and USIM\_GND less than 1μF and be placed as close to the (U)SIM card connector as possible.
- To avoid cross-talk between USIM\_DATA and USIM\_CLK, keep them away with each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array with parasitic capacitance not exceeding 15pF. The 22Ω resistors should be added in series between the module and the (U)SIM card so as to suppress the EMI spurious transmission and enhance the ESD protection. The 33pF capacitors are used for filtering interference of EGSM900. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on USIM\_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

### 3.12. USB Interface

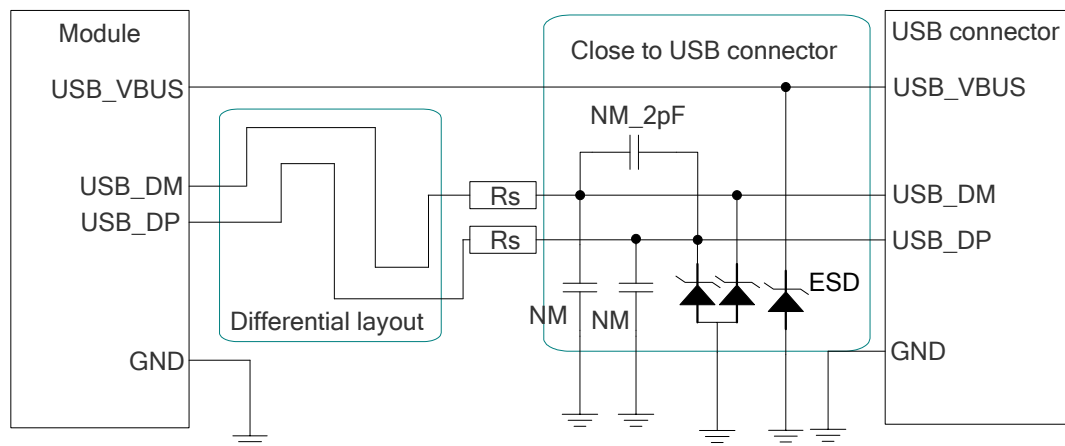
UG96 contains one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports high speed (480Mbps) and full speed (12Mbps) modes. The USB interface is used for AT command communication, data transmission, software debugging and firmware upgrade. The following table shows the pin definition of USB interface.

**Table 13: Pin Definition of USB Interface**

Pin Name	Pin No.	I/O	Description	Comment
USB_DP	9	IO	USB differential data bus (+)	Require differential impedance of 90Ω.
USB_DM	10	IO	USB differential data bus (-)	Require differential impedance of 90Ω.
USB_VBUS	8	PI	USB detection	2.5V~5.25V. Typically 5.0V.

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

The following figure shows a reference circuit of USB interface.



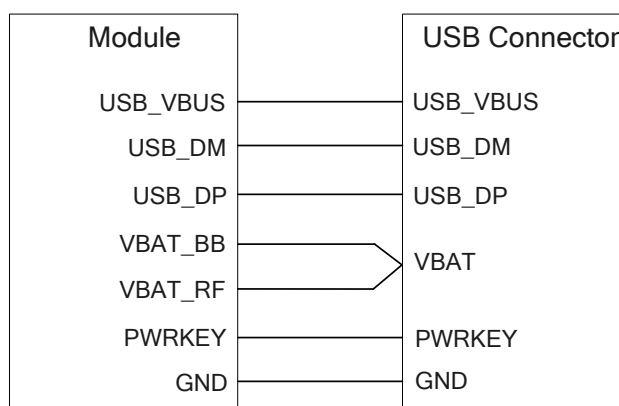
**Figure 25: Reference Circuit of USB Interface**

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

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90Ω.

- Pay attention to the influence of junction capacitance of ESD protection components on USB data lines. Typically, the capacitance value should be less than 2pF.
- Do not route signal traces under crystals, oscillators, magnetic devices or RF signal traces. It is important to route the USB differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.
- Keep the ESD protection components as close to the USB connector as possible.
- The RC circuit is suggested to be reserved near USB connector for debugging.

The USB interface is recommended to be reserved for firmware upgrade in customers' design. The following figure shows the recommended test points.



**Figure 26: Test Points of Firmware Upgrade**

#### NOTES

1. UG96 module can only be used as a slave device.
2. It is suggested that USB\_DP, USB\_DM and USB\_VBUS pins should be set as test points and be placed on DTE for debugging.
3. USB interface supports software debugging and firmware upgrade by default.

### 3.13. PCM and I2C Interfaces

UG96 provides one Pulse Code Modulation (PCM) digital interface for audio design, which supports the following modes. It also supports one I2C interface.

- Supports 16/32-bit mode with short frame synchronization. The PCM supports 32-bit mode by default. The default command for PCM codec configuration is **AT+QDAC=1**. Please refer to **document [1]** for more details.
- Supports master and slave modes.
- Supports audio sample rate 8KHz.

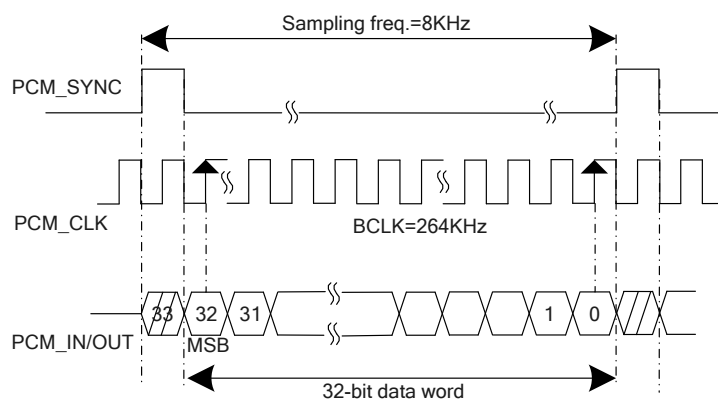
The following table shows the pin definition of PCM and I2C interfaces.

**Table 14: Pin Definition of PCM and I2C Interfaces**

Pin Name	Pin No.	I/O	Description	Comment
PCM_CLK	4	DO	PCM data bit clock	1.8V power domain
PCM_SYNC	5	DO	PCM data frame synchronization signal	1.8V power domain
PCM_IN	6	DI	PCM data input	1.8V power domain
PCM_OUT	7	DO	PCM data output	1.8V power domain
I2C_SCL	40	OD	I2C serial clock	Require external pull-up resistor.
I2C_SDA	41	OD	I2C serial data	Require external pull-up resistor.
CLK_OUT	25	DO	Clock output	Provide a digital clock output for an external audio codec. If unused, keep it open.

In PCM audio format, the MSB of the channel included in the frame (PCM\_SYNC) is clocked on the second CLK rising edge after the PCM\_SYNC pulse rising edge. The period of the PCM\_SYNC signal (frame) lasts for data word bit +1 clock pulses.

UG96's firmware has integrated the configurations on NAU8814 /ALC5616/MAX9860 application with I2C interface. **AT+QDAC** command is used to configure the external codec chip linked with PCM interface, and refer to **document [1]** for more details. Data bit is 32 bit and the sampling rate is 8KHz. The following figure shows the timing of the application with ALC5616 codec.

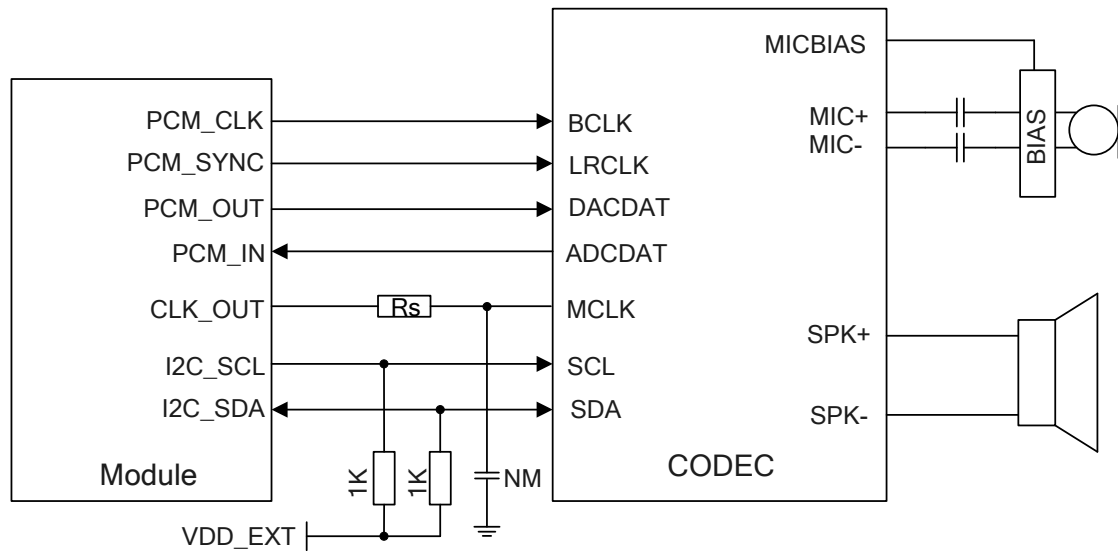


**Figure 27: PCM Master Mode Timing**

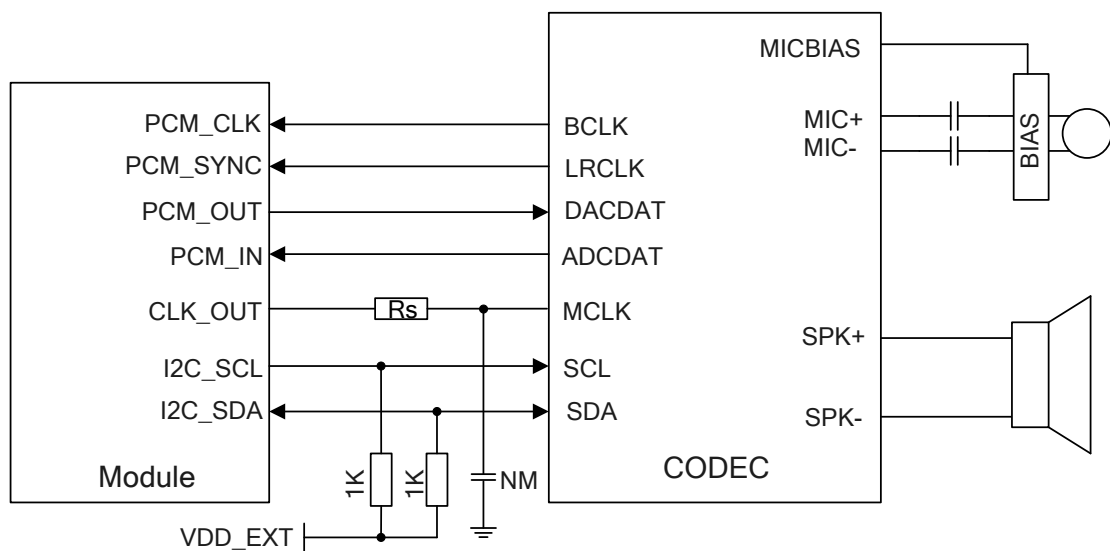
In general, the BitClockFrequency (BCLK) is calculated by the following expression:

$$\text{BitClockFrequency} = (\text{DataWordBit} + 1) \times \text{SamplingFrequency}$$

The following figure shows a reference design of PCM interface with external codec IC.



**Figure 28: Reference Circuit of PCM Master Mode Application with Audio Codec**



**Figure 29: Reference Circuit of PCM Slave Mode Application with Audio Codec**

## NOTES

1. It is recommended to reserve RC (e.g. R=22Ω, C=22pF) circuit on the PCM lines, especially for PCM\_CLK.
2. UG96 module provides a digital clock output (CLK\_OUT) for an external audio codec, the CLK\_OUT function is disabled by default. When CLK\_OUT is required, AT command is used to provide the codec with a 13/26MHz clock generated from the module. Please refer to **document [1]** for details. If unused, keep it open.
3. A RC (e.g. R=22Ω, C=47pF) circuit is recommended to be reserved on CLK\_OUT line. If external audio CODEC is MAX9860, the RC circuit should be mounted; if it is ALC5616, then it is not mounted.
4. There is a need to provide a 2.048M main clock for MCLK pin if the external audio CODEC is NAU8814.

## 3.14. Network Status Indication

The NETLIGHT signal can be used to drive a network status indication LED. The following tables describe the pin definition and logic level changes in different network status.

**Table 15: Pin Definition of NETLIGHT**

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

**Table 16: Working State of NETLIGHT**

Pin Name	Status	Description
NETLIGHT	PWM (200ms High/1800ms Low)	Network searching
	PWM (1800ms High/200ms Low)	Idle & Data transfer
	Always High	Voice & CSD calling

A reference circuit is shown in the following figure.

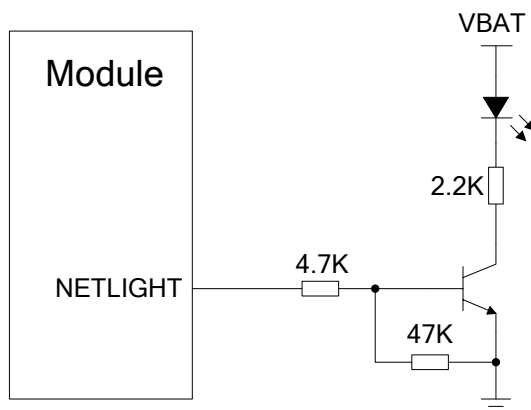


Figure 30: Reference Circuit of the Network Status Indicator

### 3.15. STATUS

The STATUS pin is used to indicate the operation status of UG96 module. It will output high level when the module is powered on.

The following table describes the pin definition of STATUS.

Table 17: Pin Definition of STATUS

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

A reference circuit is shown as following figure.

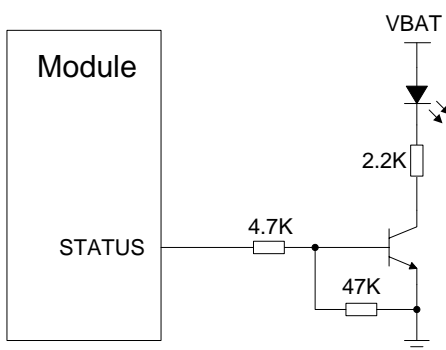


Figure 31: Reference Circuit of STATUS



# 4 Antenna Interface

UG96 includes a GSM/UMTS antenna interface. The RF interface has an impedance of 50Ω.

## 4.1. GSM/UMTS Antenna Interface

### 4.1.1. Pin Definition

The pin definition of the RF antenna is shown below.

**Table 18: Pin Definition of RF Antenna**

Pin Name	Pin No.	I/O	Description	Comment
GND	58		Ground	
GND	59		Ground	
RF_ANT	60	IO	RF antenna pad	50Ω impedance
GND	61		Ground	
GND	62		Ground	

### 4.1.2. Operating Frequency

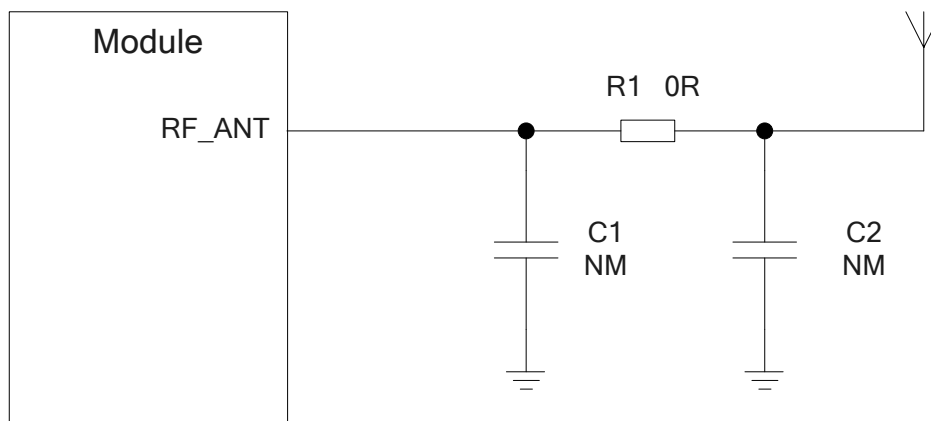
**Table 19: Module Operating Frequencies**

Band	Receive	Transmit	Unit
GSM850	869~894	824~849	MHz
EGSM900	925~960	880~915	MHz
DCS1800	1805~1880	1710~1785	MHz
PCS1900	1930~1990	1850~1910	MHz

UMTS2100	2110~2170	1920~1980	MHz
UMTS1900	1930~1990	1850~1910	MHz
UMTS900	925~960	880~915	MHz
UMTS850	869~894	824~849	MHz
UMTS800	875~885	830~840	MHz

#### 4.1.3. Reference Design of RF Antenna Interface

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



**Figure 32: Reference Circuit of RF Antenna Interface**

UG96 provides an RF antenna pad for customers' antenna connection. The RF trace in host PCB connected to the module's RF antenna pad should be micro-strip line or other types of RF traces, whose characteristic impedance should be close to 50 $\Omega$ . UG96 comes with grounding pads which are next to the antenna pad in order to give a better grounding.

#### 4.1.4. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as  $50\Omega$ . 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

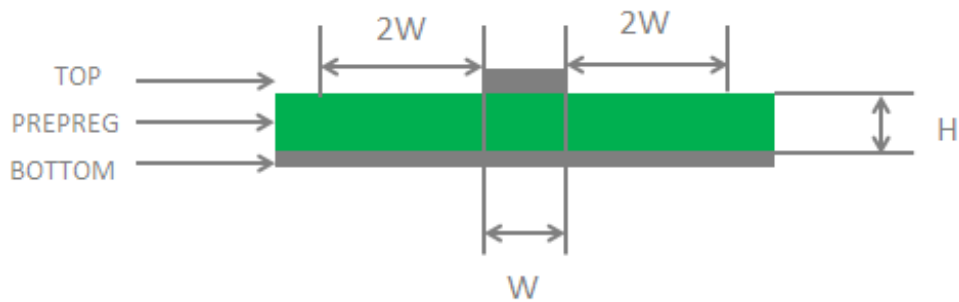


Figure 33: Microstrip Line Design on a 2-layer PCB

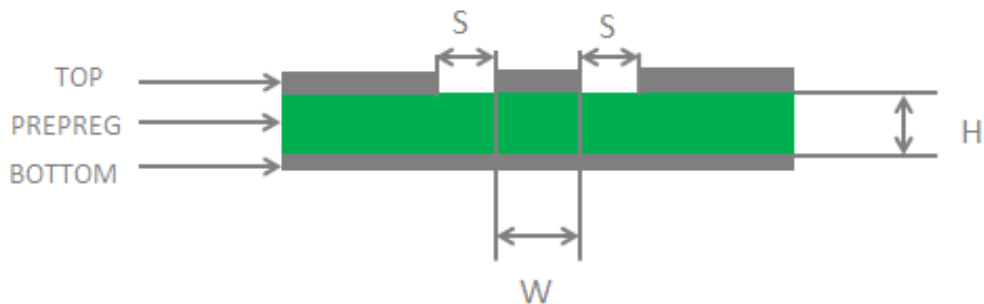
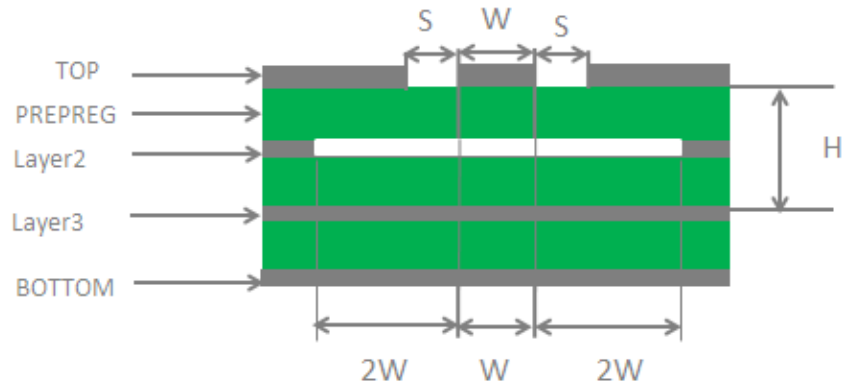
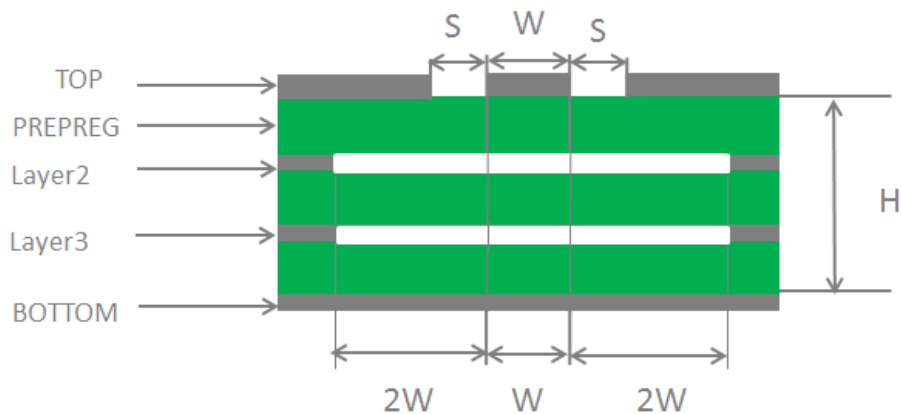


Figure 34: Coplanar Waveguide Line Design on a 2-layer PCB



**Figure 35: Coplanar Waveguide Line Design on a 4-layer PCB (Layer 3 as Reference Ground)**



**Figure 36: 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  $50\Omega$ .
- 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 [7]**.

## 4.2. Antenna Installation

### 4.2.1. Antenna Requirements

The following table shows the requirements on GSM/UMTS antenna.

**Table 20: Antenna Cable Requirements**

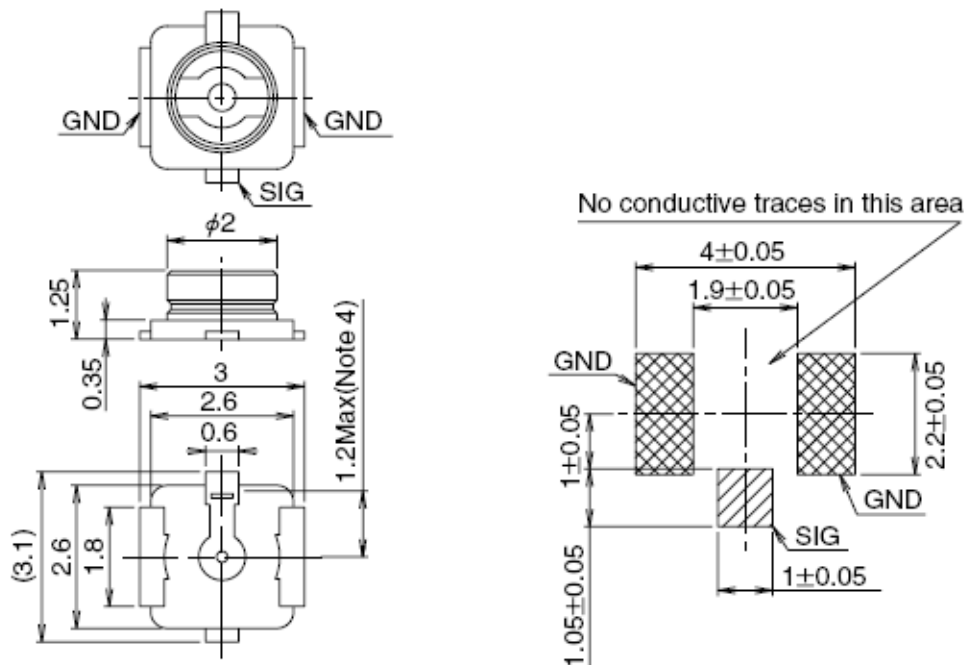
Type	Requirements
GSM850/EGSM900 UMTS800/850/900	Cable insertion loss <1dB
DCS1800/PCS1900 UMTS1900/2100	Cable insertion loss <1.5dB

**Table 21: Antenna Requirements**

Type	Requirements
Frequency Range	GSM 4-band: 850/900/1800/1900MHz UMTS 5-band: 800/850/900/1900/2100MHz
VSWR	<2:1 recommended, <3:1 acceptable
Gain (dBi)	1 typical
Max Input Power (W)	50
Input Impedance ( $\Omega$ )	50
Polarization Type	Vertical

#### 4.2.2. Recommended RF Connector for Antenna Installation

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



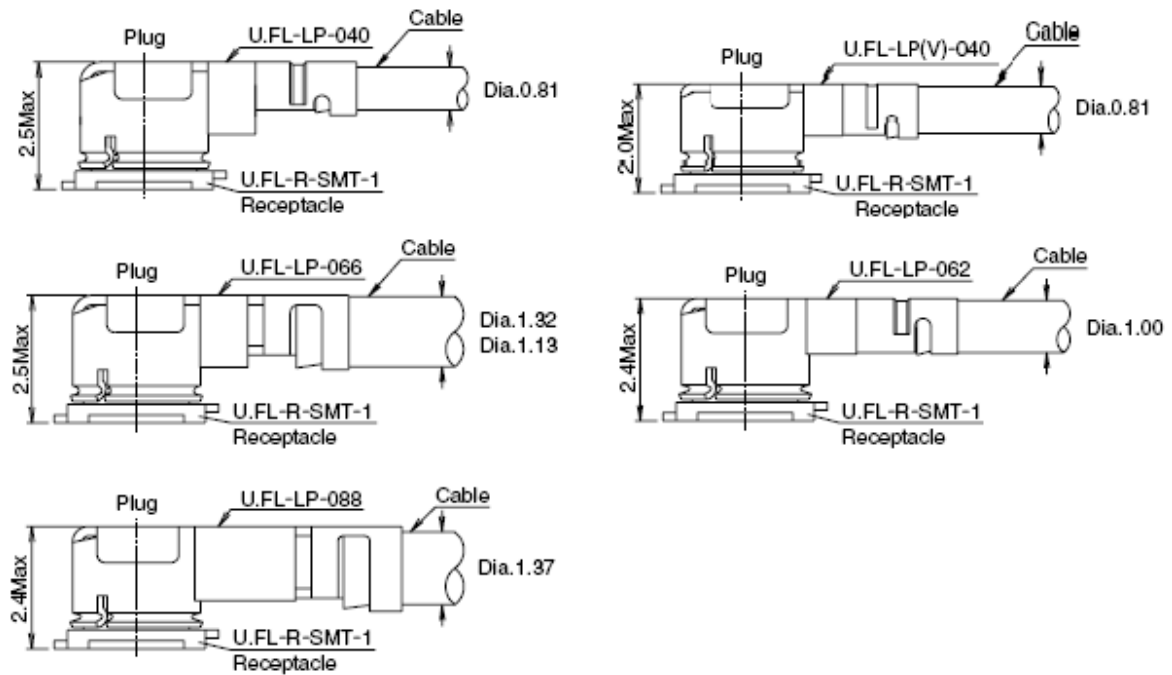
**Figure 37: Dimensions of the U.FL-R-SMT Connector (Unit: mm)**

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

	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 38: Mechanicals of U.FL-LP Connectors**

The following figure describes the space factor of mated connector



**Figure 39: 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 22: Absolute Maximum Ratings**

Parameter	Min.	Max.	Unit
VBAT_RF/VBAT_BB	-0.3	4.7	V
USB_VBUS	-0.3	5.5	V
Peak Current of VBAT_BB	0	0.8	A
Peak Current of VBAT_RF	0	2	A
Voltage at Digital Pins	-0.3	2.3	V

## 5.2. Power Supply Ratings

**Table 23: Power Supply Ratings**

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT	VBAT_BB and VBAT_RF	The actual input voltages must stay between the minimum and maximum values.	3.3	3.8	4.3	V



	Voltage drop during burst transmission	Maximum power control level on GSM900	400	mV
I <sub>BAT</sub>	Peak supply current (during transmission slot)	Maximum power control level on GSM900	1.8	2.0 A
USB_VBUS	USB detection	2.5	5.0	5.25 V

### 5.3. Operation and Storage Temperatures

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

**Table 24: Operation and Storage Temperatures**

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range <sup>1)</sup>	-35	+25	+75	°C
Extended Temperature Range <sup>2)</sup>	-40		+85	°C
Storage Temperature Range	-40		+90	°C

#### NOTES

- <sup>1)</sup> Within operation temperature range, the module is 3GPP compliant.
- <sup>2)</sup> Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, 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<sub>out</sub> 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.

## 5.4. Current Consumption

The values of current consumption are shown below.

**Table 25: Current Consumption**

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
I <sub>VBAT</sub>	OFF state supply current	Power down		50		uA
	GSM/GPRS supply current	Sleep (USB disconnected) @DRX=2		1.13		mA
		Sleep (USB disconnected) @DRX=5		1.10		mA
		Sleep (USB disconnected) @DRX=9		1.00		mA
	WCDMA supply current	Sleep (USB disconnected) @DRX=6		2.52		mA
		Sleep (USB disconnected) @DRX=7		1.82		mA
		Sleep (USB disconnected) @DRX=8		1.75		mA
		Sleep (USB disconnected) @DRX=9		1.76		mA
		Idle (USB disconnected) @DRX=6		12.4		mA
		Idle (USB connected) @DRX=6		32.1		mA
	GPRS data transfer	GSM850 1DL/1UL PCL=5		263		mA
		GSM850 5DL/1UL PCL=5		272		mA
		GSM850 4DL/2UL PCL=5		460		mA
		GSM850 3DL/3UL PCL=5		465		mA
		GSM850 2DL/4UL PCL=5		495		mA
		EGSM900 1DL/1UL PCL=5		267		mA
		EGSM900 5DL/1UL PCL=5		276		mA
		EGSM900 4DL/2UL PCL=5		475		mA

EDGE data transfer	EGSM900 3DL/3UL PCL=5	495	mA
	EGSM900 2DL/4UL PCL=5	525	mA
	DCS1800 1DL/1UL PCL=0	175	mA
	DCS1800 5DL/1UL PCL=0	193	mA
	DCS1800 4DL/2UL PCL=0	302	mA
	DCS1800 3DL/3UL PCL=0	413	mA
	DCS1800 2DL/4UL PCL=0	523	mA
	PCS1900 1DL/1UL PCL=0	189	mA
	PCS1900 5DL/1UL PCL=0	196	mA
	PCS1900 4DL/2UL PCL=0	310	mA
	PCS1900 3DL/3UL PCL=0	425	mA
	PCS1900 2DL/4UL PCL=0	545	mA
	GSM850 1DL/1UL PCL=8	187	mA
	GSM850 5DL/1UL PCL=8	199	mA
	GSM850 4DL/2UL PCL=8	308	mA
	GSM850 3DL/3UL PCL=8	417	mA
	GSM850 2DL/4UL PCL=8	528	mA
	EGSM900 1DL/1UL PCL=8	184	mA
	EGSM900 5DL/1UL PCL=8	205	mA
	EGSM900 4DL/2UL PCL=8	307	mA
	EGSM900 3DL/3UL PCL=8	420	mA
	EGSM900 2DL/4UL PCL=8	525	mA
	DCS1800 1DL/1UL PCL=2	197	mA
	DCS1800 5DL/1UL PCL=2	205	mA
	DCS1800 4DL/2UL PCL=2	312	mA

	DCS1800 3DL/3UL PCL=2	416	mA
	DCS1800 2DL/4UL PCL=2	525	mA
	PCS1900 1DL/1UL PCL=2	200	mA
	PCS1900 5DL/1UL PCL=2	207	mA
	PCS1900 4DL/2UL PCL=2	316	mA
	PCS1900 3DL/3UL PCL=2	422	mA
	PCS1900 2DL/4UL PCL=2	530	mA
WCDMA data transfer	UMTS2100 HSDPA @max power	573	mA
	UMTS2100 HSUPA @max power	540	mA
	UMTS1900 HSDPA @max power	595	mA
	UMTS1900 HSUPA @max power	567	mA
	UMTS900 HSDPA @max power	513	mA
	UMTS900 HSUPA @max power	489	mA
	UMTS850/800 HSDPA @max power	537	mA
	UMTS850/800 HSUPA @max power	493	mA
GSM voice call	GSM850 @PCL=5	238	mA
	EGSM900 @PCL=5	242	mA
	DCS1800 @PCL=0	164	mA
	PCS1900 @PCL=0	176	mA
WCDMA voice call	UMTS2100 @max power	465	mA
	UMTS1900 @max power	475	mA
	UMTS900 @max power	457	mA
	UMTS850/800 @max power	493	mA

## 5.5. RF Output Power

The following table shows the RF output power of UG96 module.

**Table 26: RF Output Power**

Frequency	Max.	Min.
GSM850	33dBm±2dB	5dBm±5dB
EGSM900	33dBm±2dB	5dBm±5dB
DCS1800	30dBm±2dB	0dBm±5dB
PCS1900	30dBm±2dB	0dBm±5dB
GSM850 (8-PSK)	27dBm±3dB	5dBm±5dB
EGSM900 (8-PSK)	27dBm±3dB	5dBm±5dB
DCS1800 (8-PSK)	26dBm±3dB	0dBm±5dB
PCS1900 (8-PSK)	26dBm±3dB	0dBm±5dB
UMTS2100	24dBm+1.7/-3.7dB	<-50dBm
UMTS1900	24dBm+1.7/-3.7dB	<-50dBm
UMTS900	24dBm+1.7/-3.7dB	<-50dBm
UMTS850/800	24dBm+1.7/-3.7dB	<-50dBm

### NOTE

In GPRS 4 slots TX mode, the maximum output power is reduced by 3.0dB. The design conforms to the GSM specification as described in **Chapter 13.16** of 3GPP TS 51.010-1.

## 5.6. RF Receiving Sensitivity

The following table shows the conducted RF receiving sensitivity of UG96 module.

**Table 27: Conducted RF Receiving Sensitivity**

Frequency	Receive Sensitivity (Typ.)
GSM850	-109.6dBm
EGSM900	-108.5dBm
DCS1800	-110dBm
PCS1900	-108dBm
UMTS850/800	-110dBm
UMTS900	-110dBm
UMTS1900	-109.5dBm
UMTS2100	-110.5dBm

## 5.7. Electrostatic Discharge

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

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

**Table 28: Electrostatic Discharge Characteristics**

Tested Point	Contact Discharge	Air Discharge
VBAT, GND	+/-4KV	+/-10KV
RF_ANT	+/-4KV	+/-8KV

---

Others

+/-0.5KV

+/-1KV

---

**NOTE**

It is recommended to add a 100nF capacitor to RESET\_N and PWRDWN\_N pins respectively to improve ESD performance.

# 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

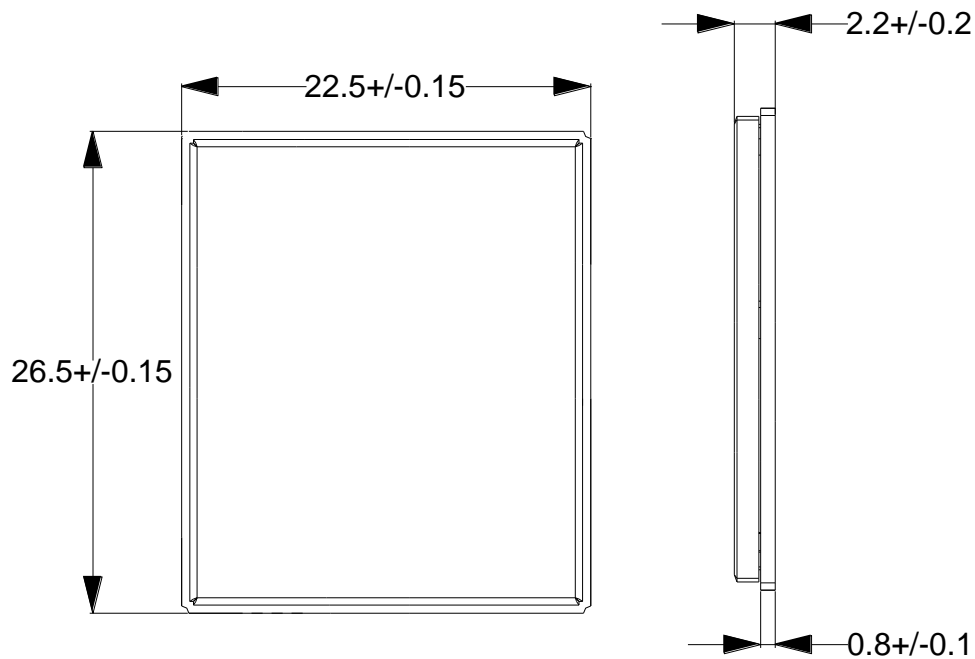


Figure 40: Module Top and Side Dimensions



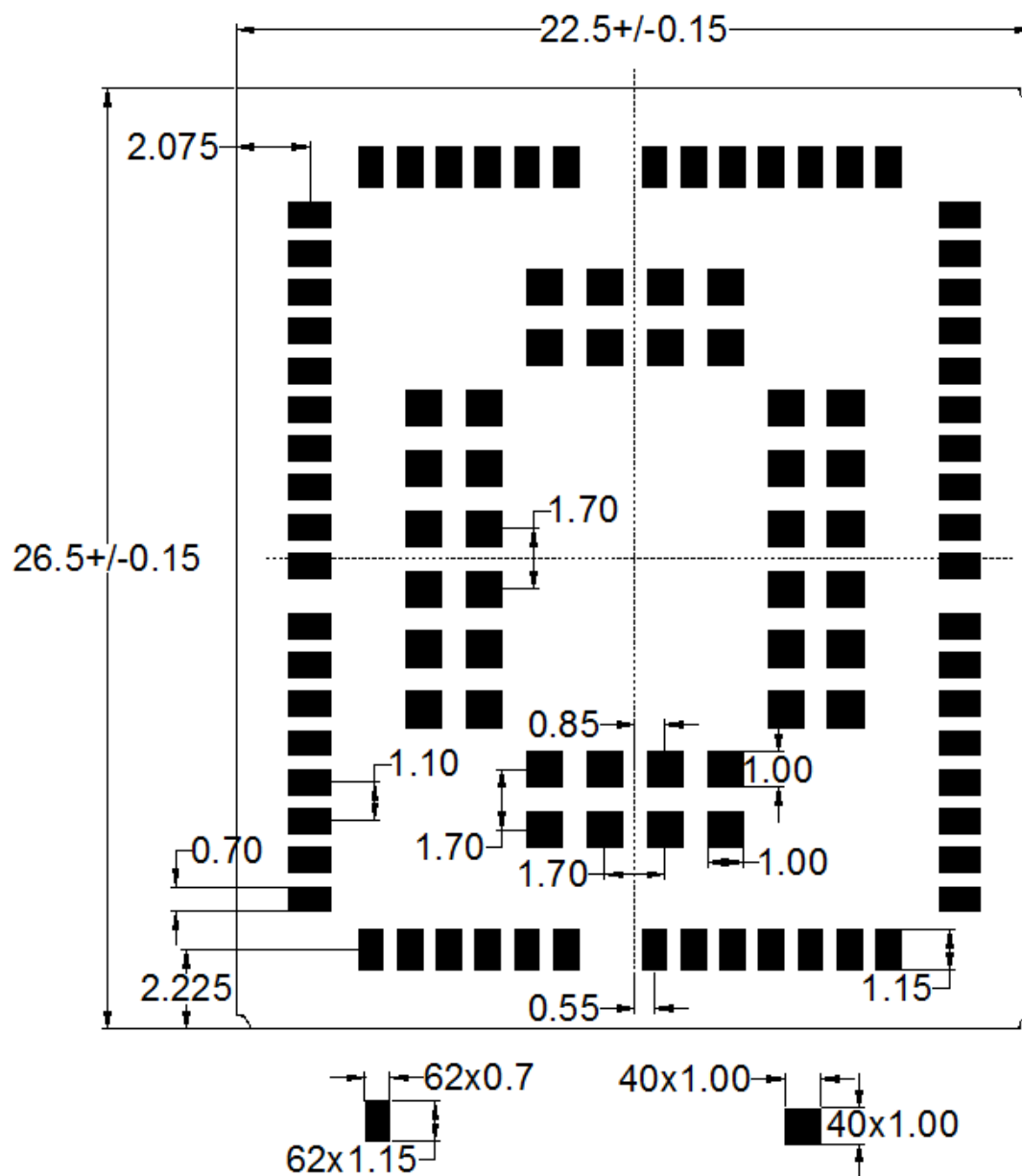


Figure 41: Module Bottom Dimensions (Top View)

## 6.2. Recommended Footprint and Stencil Design

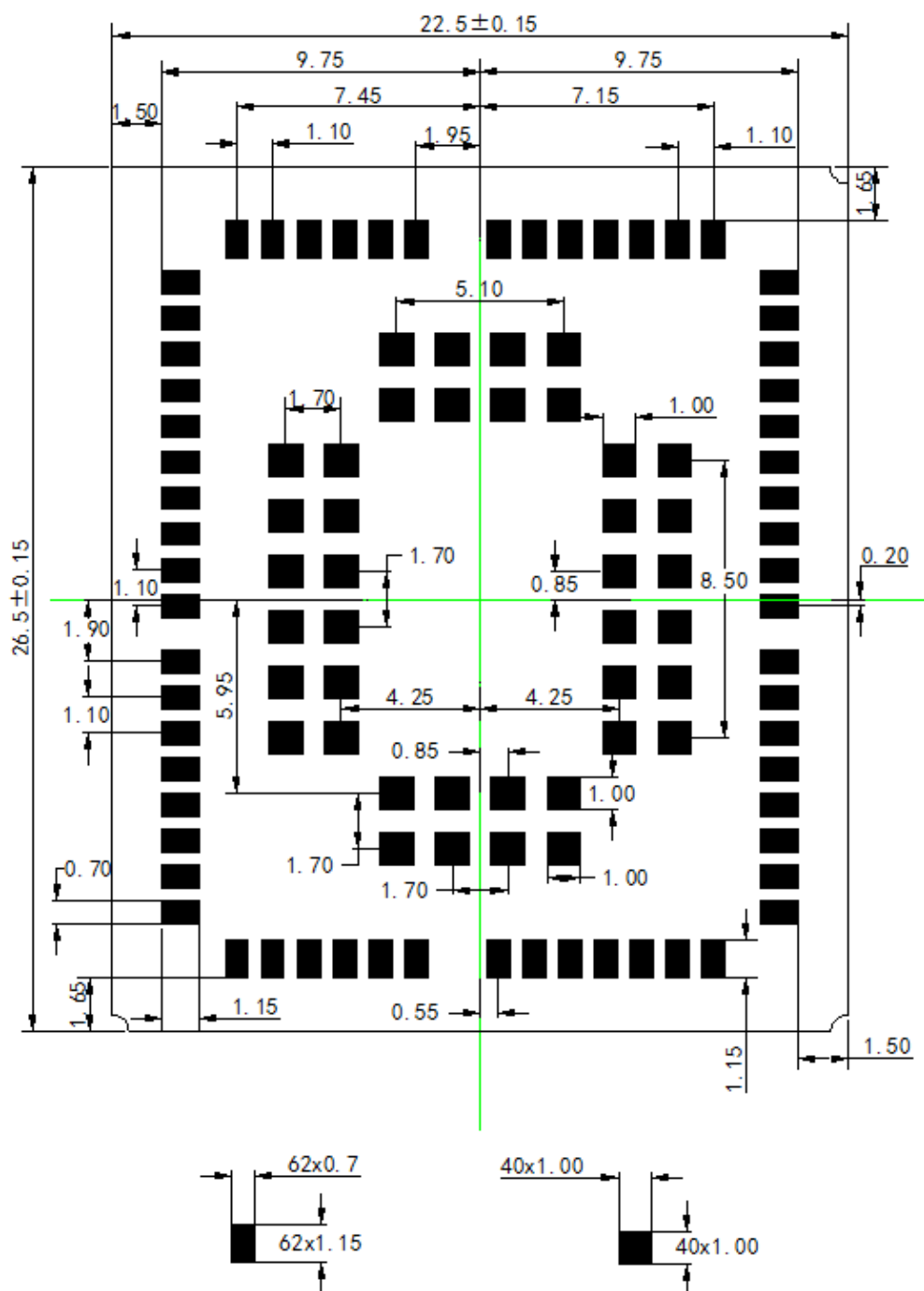


Figure 42: Recommended Footprint (Top View)

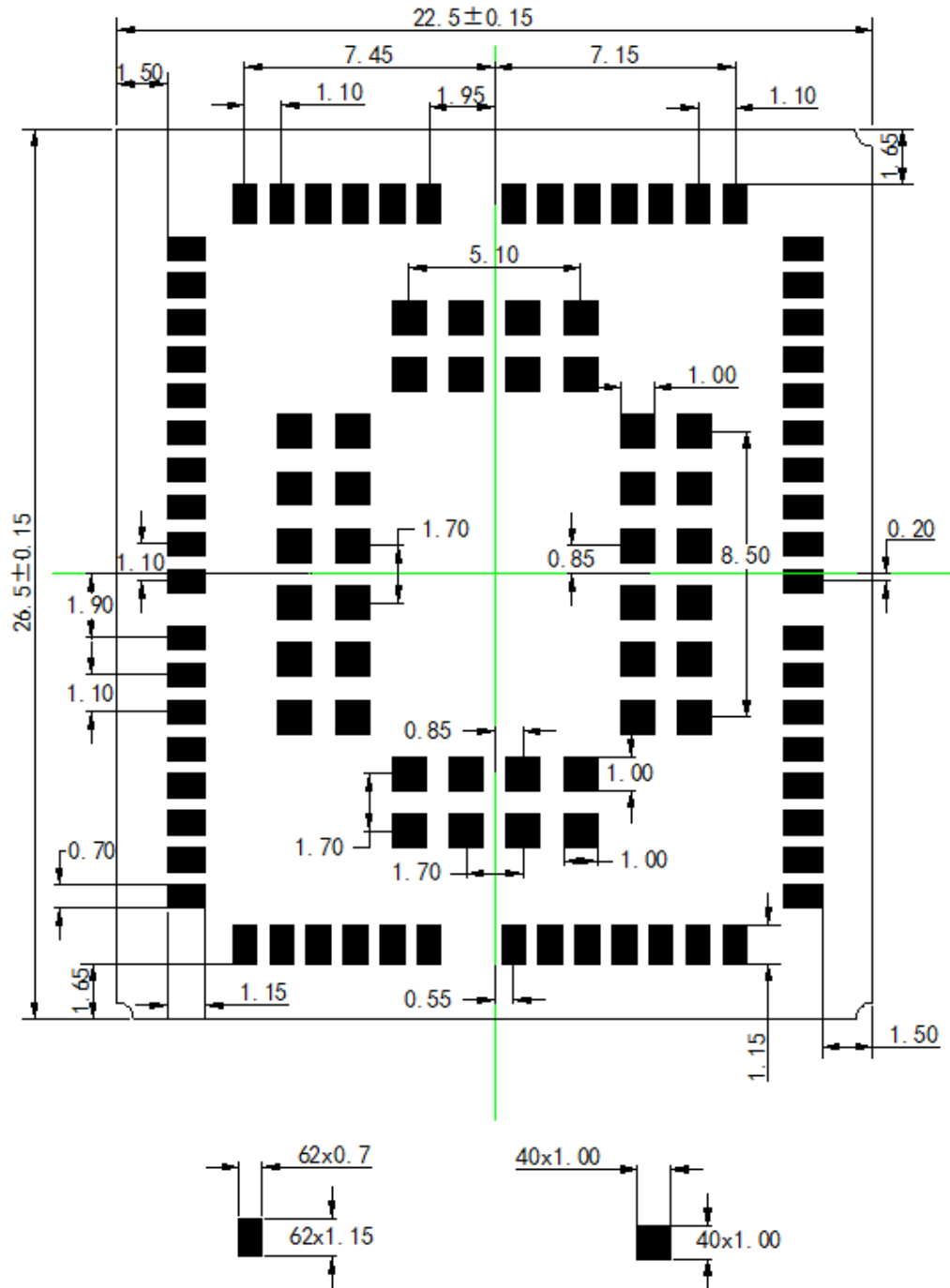


Figure 43: Recommended Stencil Design (Top View)

#### 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. Top and Bottom Views of the Module



Figure 44: Top View of the Module

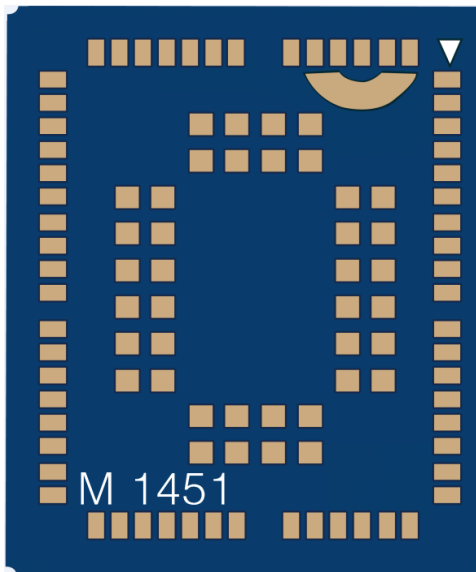


Figure 45: Bottom View of the Module

#### NOTE

These are design effect drawings of UG96 module. For more accurate pictures, please refer to the module that you get from Quectel.

# 7 Storage, Manufacturing and Packaging

## 7.1. Storage

UG96 is stored in the vacuum-sealed bag. The storage restrictions are shown as below.

1. Shelf life in the vacuum-sealed bag: 12 months at <40°C and <90%RH.
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 conditions of ≤30°C and <60%RH.
  - Stored at <10%RH.
3. Devices require baking before mounting, if any circumstance below occurs.
  - When the ambient temperature is 23°C±5°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 ≤30°C/60%RH.
4. If baking is required, devices may be baked for 8 hours at 120°C±5°C.

### NOTE

As the plastic container cannot be subjected to high temperature, it should be removed from devices before high temperature (120°C) baking. If shorter bake times are desired, please refer to *IPC/JEDECJ-STD-033* for bake 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 0.13mm. For details, please refer to **document [6]**.

It is suggested that the peak reflow temperature is 235°C~245°C (for SnAg3.0Cu0.5 alloy). The absolute maximum reflow temperature is 260°C. To avoid damage to the module caused by repeated 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:

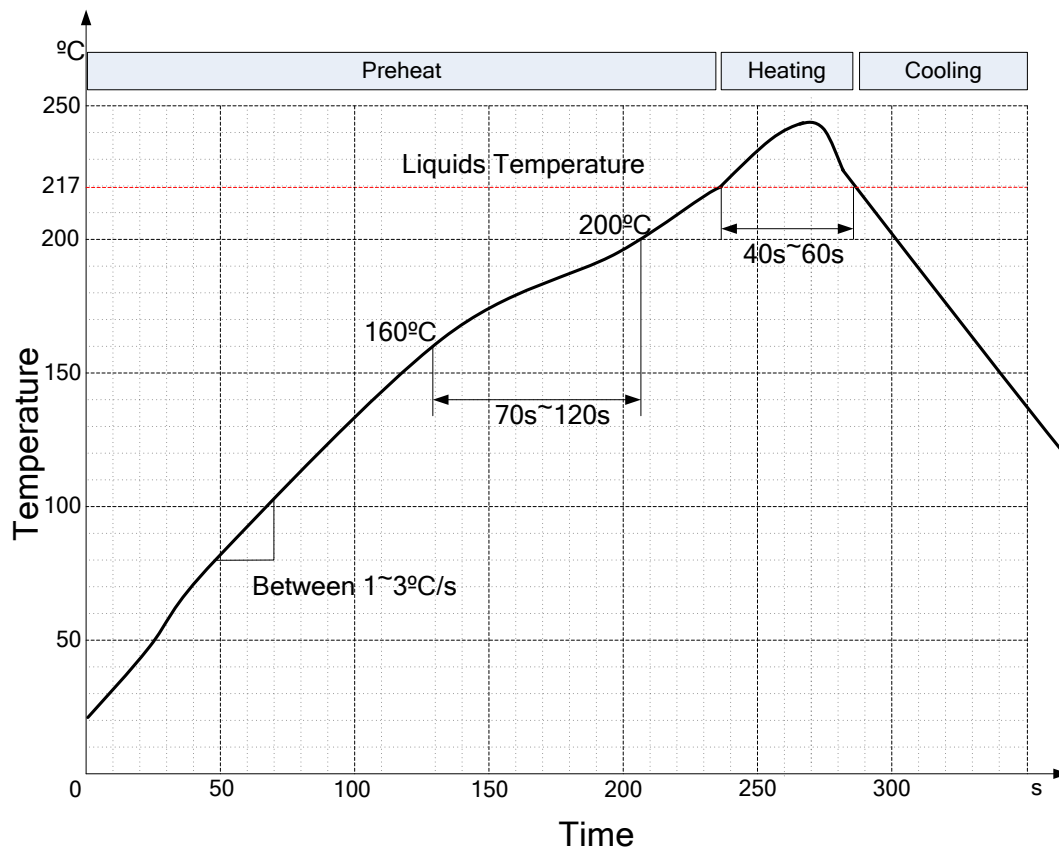


Figure 46: Reflow Soldering Thermal Profile

### 7.3. Packaging

UG96 is packaged in a vacuum-sealed bag which is ESD protected. The bag should not be opened until the devices are ready to be soldered onto the application.

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

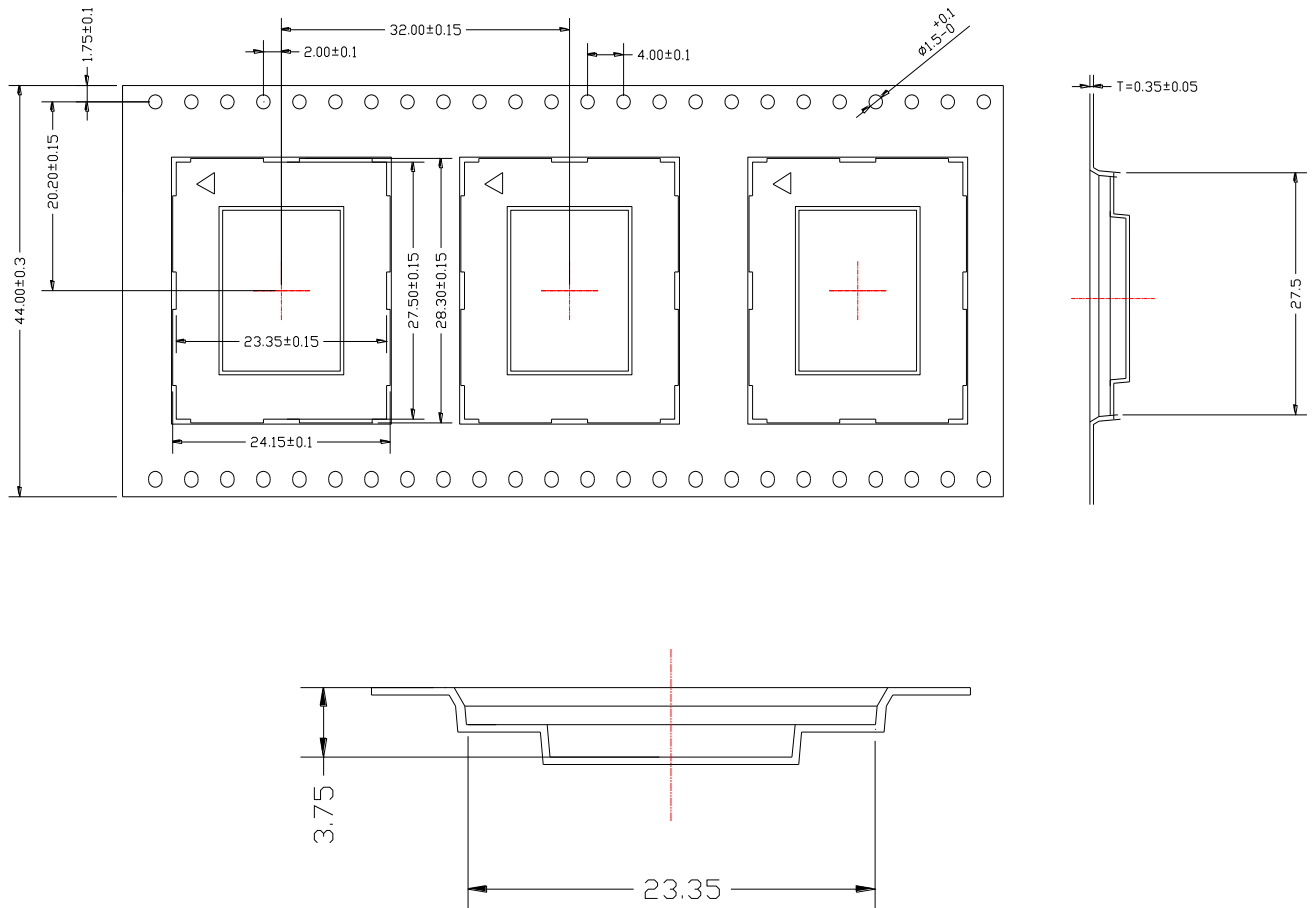
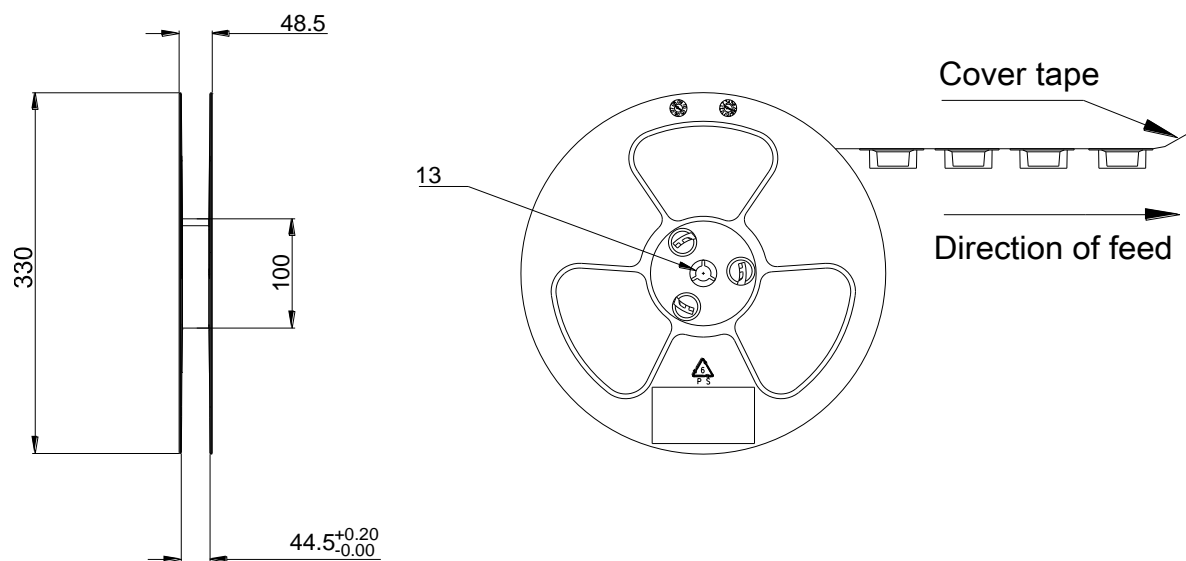


Figure 47: Tape Dimensions



**Figure 48: Reel Dimensions**

**Table 29: Reel Packing**

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package x 4=1000pcs
UG96	250pcs	Size: 370mm × 350mm × 56mm N.W: 0.78kg G.W: 1.46kg	Size: 380mm × 250mm × 365mm N.W: 3.1kg G.W: 6.45kg



# 8 Appendix A References

**Table 30: Related Documents**

SN	Document Name	Remark
[1]	Quectel_WCDMA_UGxx_AT_Commands_Manual	UGxx AT commands manual
[2]	Quectel_UMTS&LTE_EVB_User_Guide	UMTS&LTE EVB user guide
[3]	Quectel_UG96_Reference_Design	UG96 reference design
[4]	Quectel_UG96&UG95&M95 R2.0_Reference_Design	UG96, UG95 and M95 R2.0 compatible reference design
[5]	Quectel_UG96&UG95&M95 R2.0_Compatible_Design	UG96, UG95 and M95 R2.0 compatibility design specification
[6]	Quectel_Module_Secondary_SMT_User_Guide	Module secondary SMT user guide
[7]	Quectel_RF_Layout_Application_Note	RF layout application note

**Table 31: Terms and Abbreviations**

Abbreviation	Description
AMR	Adaptive Multi-rate
ARP	Antenna Reference Point
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear To Send
DRX	Discontinuous Reception
DCE	Data Communications Equipment (typically module)

DTE	Data Terminal Equipment (typically computer, external controller)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Extended GSM900 band (includes standard GSM900 band)
ESD	Electrostatic Discharge
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HR	Half Rate
HSPA	High Speed Packet Access
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
I/O	Input/Output
IMEI	International Mobile Equipment Identity
Imax	Maximum Load Current
Inorm	Normal Current
LED	Light Emitting Diode
LNA	Low Noise Amplifier
Mbps	Mbits per second
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
PAP	Password Authentication Protocol

PBCCH	Packet Broadcast Control Channel
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
PSK	Phase Shift Keying
PWM	Pulse Width Modulation
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RMS	Root Mean Square (value)
RTC	Real Time Clock
Rx	Receive
SIM	Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USIM	Universal Subscriber Identity Module
USSD	Unstructured Supplementary Service Data
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value

V <sub>min</sub>	Minimum Voltage Value
V <sub>IHmax</sub>	Maximum Input High Level Voltage Value
V <sub>IHmin</sub>	Minimum Input High Level Voltage Value
V <sub>ILmax</sub>	Maximum Input Low Level Voltage Value
V <sub>ILmin</sub>	Minimum Input Low Level Voltage Value
V <sub>Imax</sub>	Absolute Maximum Input Voltage Value
V <sub>imin</sub>	Absolute Minimum Input Voltage Value
V <sub>OHmax</sub>	Maximum Output High Level Voltage Value
V <sub>OHmin</sub>	Minimum Output High Level Voltage Value
V <sub>OLmax</sub>	Maximum Output Low Level Voltage Value
V <sub>OLmin</sub>	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access

## 9 Appendix B GPRS Coding Scheme

Table 32: Description of Different Coding Schemes

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

# 10 Appendix C GPRS Multi-slot Class

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

**Table 33: GPRS Multi-slot Classes**

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

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

# 11 Appendix D EDGE Modulation and Coding Scheme

Table 34: EDGE Modulation and Coding Scheme

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