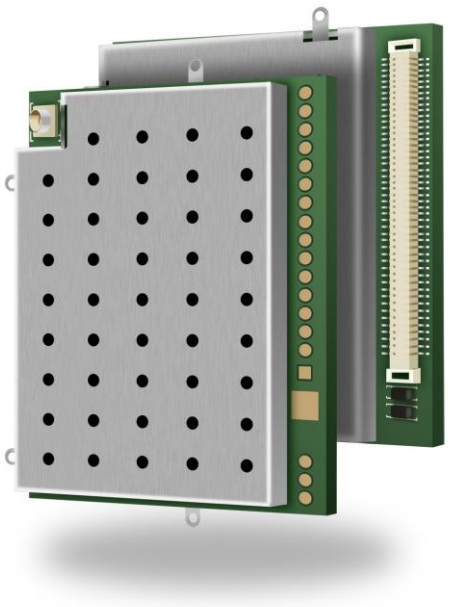
U10

Quectel Cellular Engine



Hardware Design

U10_HD_V1.0

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Contents

Table Index

Figure Index

0. Revision history

Revision	Date	Author	Description of change
V1.0	2012-03-02	Bruce YU	Initial

1. Introduction

This document defines Quectel U10 module and describes the hardware interface of U10 module that connects with the customers' application and the air interface.

This document can help customers quickly understand module interface specifications, electrical and mechanical details. Associated application notes and user guide, customers can use U10 module to design and set up mobile applications easily.

1.1. Related documents

Table 1: Related documents

SN	Document name	Remark
[1]	U10_ATC	AT commands set
[2]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[3]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[4]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[5]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[6]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[7]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[8]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information
[9]	GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification
[10]	GSM_UART_AN	UART port application notes
[11]	GSM_FW_Upgrade_AN01	GSM Firmware upgrade application note
[12]	3GPP TS 51.010-1	Digital cellular telecommunication system (release 5); Mobile Station(MS) conformance specification
[13]	3GPP TS 34.124	Electromagnetic Compatibility (EMC) for mobile

		terminals and ancillary equipment.
[14]	3GPP TS 34.121	Electromagnetic Compatibility (EMC) for mobile terminals and ancillary equipment.
[15]	3GPP TS 34.123-1	Technical Specification Group Radio Access Network; Terminal conformance specification; Radio transmission and reception (FDD)
[16]	3GPP TS 34.123-3	User Equipment (UE) conformance specification; Part 3; Abstract Test Suites.
[17]	EN 301 908-02 V2.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM). Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part2: Harmonized EN for IMT-2000, CDMA Direct Spread (UTRA FDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive
[18]	EN 301 489-24 V1.2.1	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA) for Mobile and portable (UE) radio and ancillary equipment
[19]	IEC/EN60950-1(2001)	Safety of information technology equipment(2000)
[20]	3GPP TS 51.010-1	Digital cellular telecommunications system (Release 5); Mobile Station (MS) conformance specification.
[21]	GCF-CC V3.23.1	Global Certification Forum-Certification Criteria
[22]	U10-EVB_UGD	U10- EVB user guide
[23]	WCDMA_VIDEO_CALL_AN	WCDMA Video Call application notes

1.2. Terms and Abbreviations

Table 2: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
ARP	Antenna Reference Point
ARQ	Automatic Repeat Request
ASIC	Application Specific Integrated Circuit
ATM	Asynchronous Transfer Mode
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BER	Bit Error Rate
BLER	Block Error Rate
BOM	Bill Of Material
BTS	Base Transceiver Station
CHAP	Challenge Handshake Authentication Protocol
CCCH	Common Control Channel
CCPCH	Common Control Physical Channel
CPCH	Common Packet Channel
CPICH	Common Pilot Channel
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear To Send
DAC	Digital-to-Analog Converter
DCCH	Dedicated Control Channel
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DCE	Data Communications Equipment (typically module)
DTCH	Dedicated Traffic Channel
DTE	Data Terminal Equipment (typically computer, external controller)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EC	Echo Cancellation
EFR	Enhanced Full Rate
ETSI	European Telecommunications Standards Institute
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility

Abbreviation	Description
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FACH	Forward Access Channel
FCC	Federal Communications Commission (U.S.)
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FR	Full Rate
FEC	Forward Error Correction
FTP	File Transfer Protocol
GGSN	Gateway GPRS Support Node
GMSC	Gateway Mobile-services Switching Center
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HR	Half Rate
HTTP	Hyper Text Transfer Protocol
HSPA	High Speed Package Access
HSUPA	High Speed Uplink Packer Access
HSDPA	High Speed Downlink Packet Access
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
Imax	Maximum Load Current
Inorm	Normal Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PPP	Point-to-Point Protocol
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
RX	Receive Direction
SIM	Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access

Abbreviation	Description
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
USIM	Universal Subscriber Identity Module
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
SM	SIM phonebook
NC	Not connect
EDGE	Enhanced data rates for GSM evolution
WCDMA	Wideband Code Division Multiple Access
VCTCXO	Voltage control temperature-compensated crystal oscillator

1.3. Safety cautions

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 U10 module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. If not so, Quectel does not take on any liability for customer failure to comply with these precautions.

When in a hospital or other health care facility, observe the restrictions about the use of mobile. Switch the cellular terminal or mobile off. Medical equipment may be sensitive to not operate normally for RF energy interference.

Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forget to think much of these instructions may lead to the flight safety or offend against local legal action, or both.

Do not operate the cellular terminal or mobile in the presence of flammable gas or fume. Switch off the cellular terminal when you are near petrol station, fuel depot, chemical plant or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmosphere can constitute a safety hazard.

Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.

Road safety comes first! Do not use a hand-held cellular terminal or mobile while driving a vehicle, unless it is securely mounted in a holder for hands-free operation. Before making a call with a hand-held terminal or mobile, park the vehicle.

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

Some networks do not allow for emergency call if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may have to deactivate those features before you can make an emergency call.

Also, some networks require that a valid SIM card be properly inserted in cellular terminal or mobile.

2. Product concept

U10 is a Multi-band WCDMA/GSM engine that works on GSM Quad-Band and UMTS/HSPA Triple-Band. GPRS/EDGE supports multi-slot class 12 (configurable) capability. The module supports the downlink speed of 7.2Mbps and the uplink speed of 5.76Mbps in HSPA mode. Customers can choose the dedicated type based on the wireless network configuration. The entire radio band configuration of U10 series is listed in the following table.

Table 3: U10 series product

Module	UMTS Band	GSM Band
U10-G	850/1900/2100 MHz	850/900/1800/1900 MHz
U10-E	900/2100 MHz	900/1800 MHz
U10-A	850/1900 MHz	850/900/1800/1900 MHz
U10-S	2100 MHz	900/1800MHz

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

With a compact profile of 37.7mm×29.9mm×5.0mm, U10 can meet almost all the requirements for M2M application, including Video Surveillance, Monitor and Security system, Remote Controlling, Smart Metering, Tracing and Tracking, Industrial PDA, Wireless POS, etc.

U10 is a board-to-board type module, which can be embedded into customer's application through its 100-pin board-to-board connector.

Designed with power saving technique, U10's current consumption can reach to very low level in SLEEP mode.

U10 is integrated with Internet service protocols, which are TCP/IP, UDP, FTP and PPP. Extended AT commands have been developed for customers to use these Internet service protocols easily.

The modules are fully RoHS compliant to EU regulation.

2.1. Key features

Table 4: Module key features

Feature	Implementation
Power supply	Single supply voltage: 3.4V ~ 4.6V

Feature	Implementation
	Typical supply voltage: 4V
Power saving	TBD
Frequency bands	● GSM/GPRS/EDGE Quad-band: GSM850MHz EGSM900MHz DCS1800MHz PCS1900MHz ● WCDMA/HSPA Tri-band: BAND1:2100MHz BAND2:1900MHz BAND5:850MHz ● Customers can choose appropriate module for application or network. More details please refer to table 3.
Transmit data	● GPRS DL/UL data rate:85.6kbps/ 85.6kbps ● EDGE DL/UL date rate:236.8kbps/236.84kbps ● UMTS R99 data rate :384kbps DL/UL ● HSPA R6 DL :7.2Mbps / UL:5.76Mbps (DL category 7/8, UL category 6)
Transmitting power	● Class 4 (2W) at GSM850 and GSM900 ● Class 1 (1W) at DCS1800 and PCS1800 ● Class 3 (0.25W) at UMTS
Temperature range	● Normal operation: -35 ℃ ~ +80 ℃ ● Restricted operation: -40 ℃ ~ -35 ℃ and +80 ℃ ~ +85 ℃ [1)] ● Storage temperature: -45 ℃ ~ +90 ℃
GSM DATA	GPRS: ● Support GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Support the protocols PAP (Password Authentication Protocol) and CHAP（Challenge Handshake Authentication Protocol) usually used for PPP connections. ● Internet service protocols: TCP/IP, PPP/UDP/FTP/HTTP ● Support Packet Switched Broadcast Control Channel (PBCCH) EDGE: ● Support EDGE multi-slot class 12 (default) ● Support GMSK and 8PSK for different MCS (Modulation and Coding Scheme). ● Downlink coding schemes : MCS 1-9 ● Uplink coding schemes : MCS 1-9 ● Support Packet Switched Broadcast Control Channel (PBCCH) CSD： ● CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps non-transparent ● Support Unstructured Supplementary Services Data (USSD)

Feature	Implementation
UMTS/HSPA	● UMTS data rate is corresponded with 3GPP R99, HSPA data rate is corresponded with 3GPP R6. ● Support both QPSK and 16 QAM modulation ● Support the protocols PAP (Password Authentication Protocol) and CHAP（Challenge Handshake Authentication Protocol) usually used for PPP connections ● Internet service protocols TCP/IP, PPP/UDP/FTP/HTTP ● Support CQI, and ACK/NACK on HS-DPCCH channel ● Can switch between HS-PDSCH and DPCH channel resources as directed by the network
CSD	● CSD transmission rates: 64 kbps non-transparent for multimedia
SMS	● Text and PDU mode ● SMS storage: SIM card by default ● Point to point MO and MT ● SMS Cell Broadcast
SIM interface	Support SIM card: 1.8V, 3V Support USIM and SIM
Audio features	Support two analogy input channels and two analogy output channels Audio decode: Support AAC/AMR/WB-AMR Audio encode: Support AMR/WB-AMR Support stereo Audio output Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) ● Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) ● Adaptive Multi-Rate for GSM ● AMR/WB-AMR for WCDMA ● Echo Cancellation ● Echo Suppression ● Noise Reduction
Video features	● Provide a interface for camera sensor and the resolution supports 3M pixels (YUV sensor) or 5M pixels (JPEG sensor) ● Built-in hardware-based JPEG codec, Fcore4-based MPEG-4 codec, H.263 and H.264 codec ● Support 8/10 bit Bayer format image input and YUV422 format image input ● Built-in color correction matrix and gamma correction ● Support RTP, RTCP and RTSP for Real Time multimedia applications like video call, video streaming and so on.
UART interface	Support 3 UART port: Main UART Port, Debug UART Port, Auxiliary UART Port. Main UART Port supports hardware flow control The data transfer rate can reach up to 921600 bps

Feature	Implementation
	Main UART Port: ● Seven lines on Main UART port ● Support Hardware flow control ● Baud rate can reach up to 921600 bps ● Use for AT command or data transmission ● Support autobauding from 4800 bps to 115200 bps Debug UART Port: ● Two lines on debug port interface: DBG_TXD and DBG_RXD ● Debug Port only used for software debugging Auxiliary UART Port: ● Two lines on Auxiliary port interface: AUX_TXD and AUX_RXD ● Used for AT command only
USB interface	● Compliant with USB 2.0 specification, the data transfer rate is up to 480Mbps ● Used for AT command or data transmission ● Map two COM ports on PC: modem port and application port ● Driver: Support WinXP, Win7, Linux 2.6, WinCE 6.0.
PCM	Support 13 and 16 bit linear data
Real Time Clock	Implemented
Antenna interface	Connected to antenna via 50 Ohm RF connector
Physical characteristics	Size: 37.7±0.15×29.9±0.15×5.0±0.25mm Weight: 7.0g
Firmware upgrade	Firmware upgrade via Main UART Port or USB interface

1) When the module works in this temperature range, the RF performance might degrade. For example, the frequency error or the phase error could increase.

Table 5: Coding schemes and data rates over air interface

Coding scheme	1 Timeslot	2 Timeslot	4 Timeslot
CS-1:	9.05kbps	18.1kbps	36.2kbps
CS-2:	13.4kbps	26.8kbps	53.6kbps
CS-3:	15.6kbps	31.2kbps	62.4kbps
CS-4:	21.4kbps	42.8kbps	85.6kbps
MCS-1	8.80 kbps	17.60 kbps	35.20 kbps
MCS-2	11.2 kbps	22.4 kbps	44.8 kbps
MCS-3	14.8 kbps	29.6 kbps	59.2 kbps
MCS-4	17.6 kbps	35.2 kbps	70.4 kbps
MCS-5	22.4 kbps	44.8 kbps	89.6 kbps
MCS-6	29.6 kbps	59.2 kbps	118.4 kbps

MCS-7	44.8 kbps	89.6 kbps	179.2 kbps
MCS-8	54.4 kbps	108.8 kbps	217.6 kbps
MCS-9	59.2 kbps	118.4 kbps	236.8 kbps

2.2. Functional diagram

The following figure shows a block diagram of the U10 module and illustrates the major functional parts:

- Power Management
- Base Band
- DDR+NAND Flash
- Radio Frequency
- Peripheral Interface
  —Charging Interface
  —PCM Interface
  —SD Card Interface
  —SIM Card Interface
  —Camera Interface
  —Audio Interface
  —UART Interface
  —Power Supply
  —USB Interface
  —RF Interface
  —BT Function

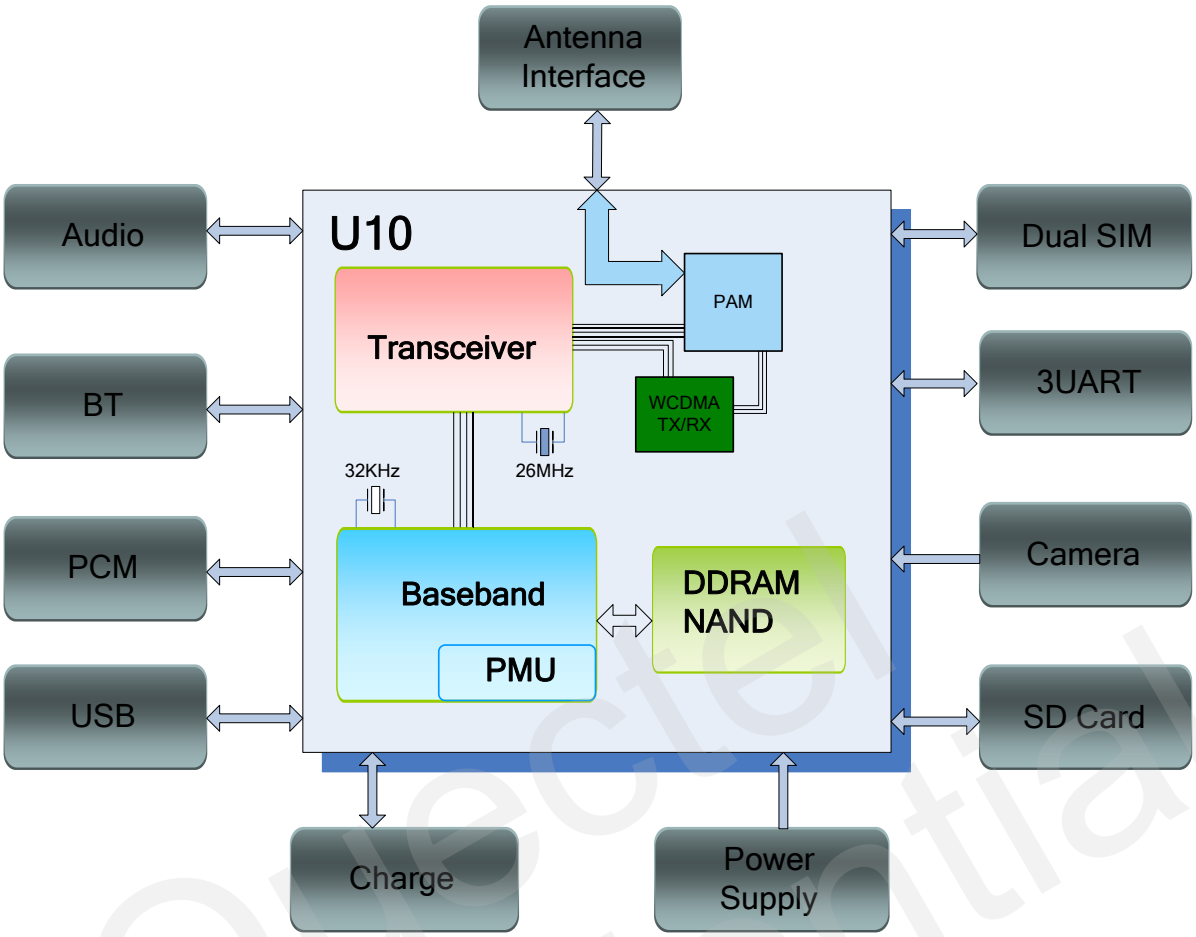


Figure 1: Module functional diagram

2.3. Evaluation board

In order to help customer to develop applications with U10, Quectel supplies Evaluation Board (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 the ***document [22]***.

3. Application interface

U10 module is equipped with a 100-pin 0.5mm pitch board-to-board connector that connects to the customer's host board. Table 6 shows pin assignment of the module.

Table 6: U10 Pin assignment

AGND	1	2	VDD _EXT
MIC2N	3	4	PWRKEY
MIC2P	5	6	RESERVED
SPK2R	7	8	EMERG_OFF
SPK2L	9	10	RESERVED
MIC1P	11	12	RESERVED
MIC1N	13	14	RESERVED
SPK1P	15	16	CAM_PWR_EN
SPK1N	17	18	RESERVED/SIM2_CLK
RI	19	20	RESERVED/SIM2_RST
STATUS	21	22	RESERVED/SIM2_VDD
ADC0	23	24	RESERVED/SIM2_DATA
ADC1	25	26	VCAMA
DTR	27	28	VCAMD
RESERVED	29	30	CS_D 0
RESERVED	31	32	CS_D 1
RESERVED	33	34	CS_D 4
RESERVED	35	36	CS_D 3
CS_SCL	37	38	CS_D 5
CS_SDA	39	40	CS_D 2
SD_DATA1	41	42	CS_D 6
SD_DATA0	43	44	CS_PCLK
SD_CLK	45	46	CS_D 7
SD_CLK_FB	47	48	CS_D 8
SD_VDD	49	50	CS_MCLK
SD_CMD	51	52	CS_D9
SD_DATA3	53	54	CS_VSYNC
SD_DATA2	55	56	CS_HSYNC
USB_DM	57	58	CS_PWDN
USB_DP	59	60	CS_RST
SIM1_GND	61	62	RESERVED
SIM1_PRESENCE	63	64	USB_VBUS
SIM1_VDD	65	66	RESERVED

SIM1_DATA	67	68	NETLIGHT1
SIM1_RST	69	70	RESERVED
SIM1_CLK	71	72	USB_DL
RESERVED	73	74	PCM_OUT
RESERVED	75	76	DBG_RXD
RESERVED	77	78	DBG_TXD
AUX _TXD/PCM_SYNC	79	80	NETLIGHT2
AUX _RXD/PCM_IN	81	82	CTS
RESERVED	83	84	RXD
DCD	85	86	RTS/PCM_CLK
VRTC	87	88	TXD
GND	89	90	GND
GND	91	92	GND
VCHG	93	94	GND
VCHG	95	96	VBAT
VBAT	97	98	VBAT
VBAT	99	100	VBAT

Note: Keep all reserved pins open.

3.1. Pin description

The follow table shows the U10's pin definition.

Table 7: Pin description

Power Supply					
PIN NAME	PIN No.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
VBAT	96, 97, 98, 99, 100	I	These pins are dedicated to connect the power supply source for the module.	$V_I$max= 4.6V $V_I$min=3.4V $V_I$norm=4.0V	It must be able to provide sufficient current during the transmitting slot which typically rises to 1.6A.
VCHG	93, 95	I	Voltage input for the charging circuit	Vmax=7.0V Vmin=1.1 * VBAT Vnorm=5.0V	If unused, keep these pins open.
VRTC	87	I/O	Power supply for RTC when VBAT is not supplied for the system. Charging for	$V_I$max=VBAT $V_I$min=2.0V $V_I$norm=2.8V $V_O$min=2V $V_O$max=3V	Recommended to connect to a backup battery or a Large-capacitance Capacitor

			backup battery or a Large-capacitance Capacitor when the VBAT is present.	$V_O$norm=2.8V Iout= 1mA	If unused, keep this pin open.
VDD_ EXT	2	O	Supply 2.8V voltage for external circuit.	$V_O$max=2.9V $V_O$min=2.7V $V_O$norm=2.8V Imax=20mA	1. If unused, keep this pin open. 2. Recommend to add a 2.2~4.7uF bypass capacitor when using this pin for power supply.
GND	89, 90, 91, 92, 94		Ground		
Power on /off					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
PWR KEY	4	I	Power on/off key. PWRKEY should be pulled down for a moment to turn on or off the system.	V_{IL}max=0.3*VBAT V_{IH}min=0.7*VBAT $V_I$max=VBAT	Pull up to high level internally. Open drain/collector driver required in cellular device application.
EMERG_ OFF	8	I	Emergency off. Pulled down for at least 20ms, the module will be turned off in case of emergency. Use it only when normal shutdown through PWRKEY or AT command cannot perform well.	V_{IL}max=0.27V V_{IH}min=1.53V V_{open}=1.8V	Pulled up to 1.8V internally Open drain/collector driver required in cellular device application. If unused, keep this pin open.
Module status indication					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
STATUS	21	O	Used to indicate module operating	V_{OL}min=GND V_{OL}max=0.15*VDD_	If unused, keep this pin open.

			status. High level indicates module in power-on state and low level indicates module in power-down state.	EXT V_{OH}min=0.85*VDD_EXT	
NETLIGHT 1	68	O	Network status indication	V_{OL}max=0.27V V_{OH}min=1.53V	If unused, keep this pin open. This pin is a 1.8V power domain pin.
NETLIGHT 2	80	O	Network status indication	V_{OL}max=0.27V V_{OH}min=1.53V	If unused, keep this pin open. This pin is a 1.8V power domain pin.
Main UART Port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
RXD	84	I	Receive data	V_{IL}min=-0.3V V_{IL}max=0.25*VDD_EXT V_{IH}min=0.75*VDD_EXT V_{IH}max=VDD_EXT+0.3V V_{OL}min=GND V_{OL}max=0.15*VDD_EXT V_{OH}min=0.85*VDD_EXT V_{OH}max=VDD_EXT	If only the TXD, RXD and GND are used, it is recommended to keep other pins open，except RTS. Pull down RTS to GND.
TXD	88	O	Transmit data		
RTS /PCM_CLK	86	I	Request to send, this pin is multiplexed with PCM_CLK		
CTS	82	O	Clear to send		
DTR	27	I	Data terminal ready		
RI	19	O	Ring indicator		
DCD	85	O	Data carrier detection		
Debug UART Port					
DBG_TXD	78	O	Transmitting data for debug only.	V_{IL}min=-0.3V V_{IL}max=0.25*VDD_EXT V_{IH}min=0.75*VDD_EXT V_{IH}max=VDD_EXT+0.3V V_{OL}min=GND V_{OL}max=0.15*VDD_EXT V_{OH}min=0.85*VDD_EXT V_{OH}max=VDD_EXT	If unused, keep this pin open.
DBG_RXD	76	I	Receiving data for debug only.		

AUX UART Port					
AUX _TXD /PCM_ SYNC	79	O	Transmitting data for At command only. This pin is multiplexed with PCM_SYNC	V_{IL}min=-0.3V V_{IL}max=0.25*VDD_ EXT V_{IH}min=0.75*VDD_ EXT V_{IH}max= VDD_EXT+0.3V V_{OL}min=GND V_{OL}max=0.15*VDD_ EXT V_{OH}min=0.85*VDD_ EXT V_{OH}max=VDD_EXT	If unused, keep this pin open.
AUX _RXD /PCM_IN	81	I	Receiving data for At command only. This pin is multiplexed with PCM_IN		
PCM interface （Multiplexed with UART）					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
AUX _TXD /PCM_ SYNC	79	I O	PCM transmit frame sync pin. This pin synchronizes the transmitting data and receiving data bytes. PCM_SYNC is multiplexed with AUX_TXD	V_{IL}min=-0.3V V_{IL}max=0.25*VDD_ EXT V_{IH}min=0.75*VDD_ EXT V_{IH}max= VDD_EXT+0.3V V_{OL}min=GND V_{OL}max=0.15*VDD_ EXT V_{OH}min=0.85*VDD_ EXT V_{OH}max=VDD_EXT	
AUX _RXD /PCM_ IN	81	I	Data input of PCM interface. PCM_IN is multiplexed with AUX_RXD		
RTS /PCM_ CLK	86	O	PCM system master clock output. PCM_CLK is multiplexed with RTS		
PCM_ OUT	74	O	Data output from PCM interface		
SIM interface					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
SIM1_ GND	61		Specified ground for SIM card		

SIM1_VDD	65	O	Power supply for SIM card	Either 1.8V or 3V is supported by the module automatically.	All traces of SIM interface should be protected against ESD with a TVS diode array. Maximum cable length from the module pad to SIM card holder is recommended to be less than 200mm.
SIM1_ DATA	67	I/ O	SIM data	3V: $V_L$max=0.4V $V_H$min=VSIM-0.4V 1.8V: $V_L$max=0.15*VSIM $V_H$min=VSIM-0.4V	
SIM1_CLK	71	O	SIM clock	3V: $V_L$max=0.4V $V_H$min=0.9*VSIM 1.8V: $V_L$max=0.12*VSIM $V_H$min=0.9*VSIM	
SIM1_RST	69	O	SIM reset	3V: $V_L$max=0.36V $V_H$min=0.9*VSIM 1.8V: $V_L$max=0.2*VSIM $V_H$min=0.9*VSIM	
SIM1_ PRESENCE	63	I	SIM card detection	V_{IL}min=-0.3V V_{IL}max= 0.25*VDD_EXT V_{IH}min= 0.75*VDD_EXT V_{IH}max= VDD_EXT+0.3	If unused, keep this pin open.
Audio interface					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
AGND	1		Specified ground for audio interface.		If unused, keep these pins open.
MIC1P	11	I	Differential input of channel 1 for microphone.		If unused, keep these pins open.
MIC1N	13				
MIC2N	3	I	Differential audio input of channel 2 for microphone.		
MIC2P	5				
SPK1P	15	O	differential audio output of channel 1		If unused, keep these pins open.
SPK1N	17				

SPK2R	7	O	Right channel of stereo audio		
SPK2L	9	O	Left channel of stereo audio		
ADC interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
ADC0	23	I	General purpose analog to digital converter.	Voltage range: 0V to 2.5V	If unused, keep these pins open.
ADC1	25	I	General purpose analog to digital converter.	Voltage range: 0V to 2.5V	If unused, keep these pins open.
SD Card interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
SD_VDD	49	O	Power supply for SD card	Typically SD_VDD=3.3V	If unused, keep these pins open.
SD_DATA0	43	I/O	DATA bit0 of SD card interface	V_{IL}max=0.25* SD_VDD V_{IH}min=0.75* SD_VDD V_{OL}max=0.15* SD_VDD V_{OH}min=0.85* SD_VDD	
SD_DATA1	41	I/O	DATA bit1 of SD card interface		
SD_DATA2	55	I/O	DATA bit2 of SD card interface		
SD_DATA3	53	I/O	DATA bit3 of SD card interface		
SD_CMD	51	I/O	Command pin for SD card		
SD_CLK	45	O	Clock pin for SD card		
SD_CLK_FB	47	I	Clock feedback pin for SD card		
USB interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
USB_VBUS	64	I/O	Used for detecting the USB cable inserting.	Typically USB_VBUS=5V Vmax=7V Vmin=4.4V	
USB_DP	59	I/O	USB differential data bus (positive side)	They are compliant with USB 2.0 standard specification.	

USB_DM	57	I/O	USB differential data bus (minus side)		
USB_DL	72	I	USB download control pin for firmware update only. It is High actively.	V_{IL}=4.4V V_{IH}=7V V_{IN}norm=5V	If unused, please keep this pin open.
Camera interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
CAM_ PWR_EN	16	O	External LDO control pin for camera analog power. High enable.	V_{OL}max= 0.4V V_{OH}min=1.53V	This pin is a 1.8V power domain pin.
VCAMA	26	O	Power supply for camera digital IO circuit.	$V_O$max=1.89V $V_O$min=1.71V Vnorm=1.8V $I_O$max=100mA	
VCAMD	28	O	Power supply for camera digital core circuit.	$V_O$max=1.57V $V_O$min=1.42V Vnorm=1.5V $I_O$max=100mA	If use external ISP, please check the current consumption of the sensor.
CS_SCL	37	O	I2C clock Pin for Camera	V_{IL}min=-0.3V V_{IL}max= 0.25*VCAMA V_{IH}min= 0.75*VCAMA V_{IH}max= VCAMA+0.3 V_{OH}min= 0.85*VCAMA V_{OL}max= 0.15*VCAMA	If unused, keep these pins open. If used , please pull up to VCAMA with 4.7KR resistor.
CS_SDA	39	I/O	I2C data Pin for Camera		
CS_D0	30	I	Pixel data bit 0 from sensor	V_{IL}min=-0.3V V_{IL}max= 0.25*VCAMA V_{IH}min= 0.75*VCAMA V_{IH}max= VCAMA+0.3 V_{OH}min=	If unused, keep these pins open.
CS_D1	32	I	Pixel data bit 1 from sensor		
CS_D4	34	I	Pixel data bit 4 from sensor		
CS_D3	36	I	Pixel data bit 3 from sensor		

CS_D5	38	I	Pixel data bit 5 from sensor	0.85*VCAMA V_{OL}max= 0.15*VCAMA	
CS_D2	40	I	Pixel data bit 2 from sensor		
CS_D6	42	I	Pixel data bit 6 from sensor		
CS_PCLK	44	I	Pixel clock from camera sensor		
CS_D7	46	I	Pixel data bit 7 from sensor		
CS_D8	48	I	Pixel data bit 8 from sensor		
CS_MCLK	50	O	Master clock to the camera sensor		
CS_D9	52	I	Pixel data bit 9 from sensor		
CS_ VSYNC	54	I	Vertical sync from camera sensor		
CS_ HSYNC	56	I	Horizontal sync from camera sensor		
CS_PWDN	58	O	This pin is used to turn off the camera. Low level is normal mode while high level is standby mode.		
CS_RST	60	O	Set this pin to low level for a certain time to reset the camera		
Reserved pin					
PIN NAME	PIN NO.	I/ O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
Reserved	6, 10, 12, 14, 18, 20, 22, 24,				

	29, 31, 33, 35, 62, 66, 70, 73, 75, 77, 83				

3.2. Operation modes

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

Table 8: Overview of operation modes

Mode	Function	
GSM mode	GSM IDLE	Software is active. The module has registered to the GSM network, and the module is ready to send and receive data.
	GSM TALK	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 mode	GPRS IDLE	The module is ready for GPRS data transfer, but no data transfer is going on. In this case, power consumption depends on network setting and GPRS configuration.
	GPRS DATA	There is GPRS data in transfer（PPP or TCP or UDP）. In this mode, power consumption is decided by the PCL, working RF band and GPRS multi-slot configuration.
EDGE mode	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 depends on network settings and EDGE configuration.
	EDGE DATA	There is data in transfer（PPP or TCP or UDP）in EDGE mode. In this mode, power consumption is decided by the PCL, uplink/downlink data rates and EDGE configuration.
WCDMA mode	WCDMA IDLE	Software is active. The module has registered to the 3G network and the module is ready to send and receive data.
	WCDMA TALK	WCDMA connection is ongoing. In this mode, the power consumption is decided by the output power of transmitting

Mode	Function	
	WCDMA DATA	There is WCDMA data in transfer. In this mode, power consumption is decided by the output power of transmitting.
HSPA mode	HSPA IDLE	Software is active. The module has registered to the 3G HSPA network, and the module is ready to send and receive data.
	HSPA DATA	There is HSPA data in transfer. In this mode, power consumption is decided by the network setting and output power.
SLEEP mode	When customer uses the UART port, the module will automatically go into SLEEP mode if DTR is set to high level and there is no interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. During SLEEP mode, the module can still receive paging message and SMS from the network normally. USB sleep mode will be supported in the later version.	
POWER DOWN mode	Power down can be achieved by sending the 'AT+QPOWD=1' command using the PWRKEY or the EMERG_OFF[1)]. The power management unit shuts down the power supply for the base band part of the module, and only the power supply for the RTC remains. Software is not active. The serial interfaces are not accessible. Operating voltage (connected to VBAT) remains applied.	
Minimum functionality mode	'AT+CFUN' command can set the module to a minimum functionality mode without removing the power supply. In this case, the RF part of the module will not work or the SIM card will not be accessible, or both RF part and SIM card will be closed, but the serial port is still accessible. The power consumption in this case is very low.	

1) Use the EMERG_OFF pin only while failing to turn off the module by the command 'AT+QPOWD=1' and the PWRKEY pin. Please refer to Chapter 3.4.2.

3.3. Power supply

3.3.1. Power supply pins

There are five VBAT pins dedicated to connect with the external power supply. Five GND pins are recommended for grounding.

Table 9: VBAT and GND pins

Pin Name	Pin NO.	Function
VBAT	96,97,98,99,100	Power supply pins for the module
GND	89,90,91,92,94	Ground

3.3.2. Feature of power supply

When the module works in GSM network, the current can reach at least 1.6A. This sudden change of current will cause obvious voltage drop at the power supply. The following figure shows the VBAT voltage and current ripple at the maximum power transmitting phase in GSM.

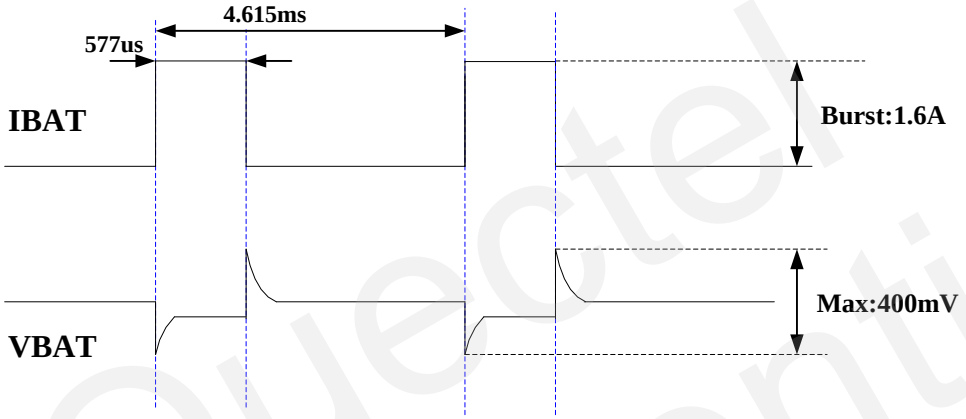


Figure 2: Ripple in supply voltage during transmitting burst

When the module works in WCDMA mode, the voltage drop at the power supply is not obvious like GSM because the transmitting current is much lower. The following figure shows the VBAT voltage and current ripple during WCDMA power transmitting.

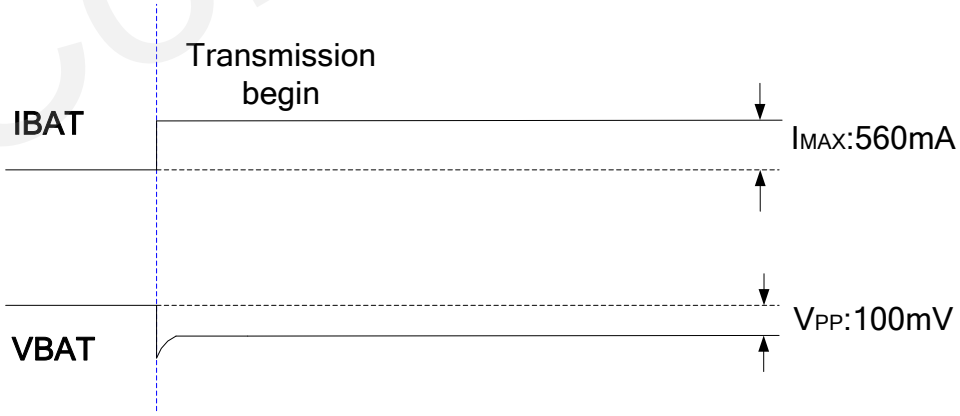
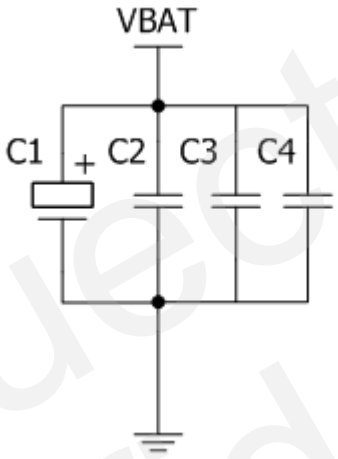


Figure 3: Voltage drop during WCDMA transmitting

Note: The test condition is VBAT=4.0V, VBAT maximum output current =2A, C1=100μF tantalum capacitor (ESR=0.7Ω) and C2=1μF.

3.3.3. Minimize supply voltage drop

The power supply range of the module is 3.4V~ 4.6V. Because of the voltage drop during the transmitting time, a bypass capacitor of about 100 μF with low ESR should be used. Multi-layer ceramic chip (MLCC) capacitor can provide the best combination of low ESR. Three ceramic capacitors (100nF, 33pF, 10pF) are recommended to be applied to the VBAT pin.The capacitors should be placed close to the U10 VBAT pins. The following figure is the reference circuit of the VBAT pin.



C1>=100uF; C2=0.1uF~1uF; C3=33pF; C4=10pF

Figure 4: Reference circuit of the VBAT input

Please pay special attention to the power supply design for applications. Make sure the input voltage will never drop below 3.4V. If the voltage drops below 3.4V, the module will turn off automatically. The PCB traces from the VBAT pin to the power source must be wide enough to ensure that there isn't too much voltage drop occurs in the transmitting procedure. The width of trace should be no less than 2mm and the principle of the VBAT trace is the longer, the wider.

3.3.4. Reference power design for module

The circuit of the power supply for the module largely depends on the power source. Figure 5 shows a reference design of +5V input power source. The designed output for the power supply is 4.16V, thus a linear regulator can be used. If there's a big voltage difference between the input source and the desired output (VBAT), a switching converter power supply would be preferable for its better efficiency.

One thing needs to be noted here is that U10 has lower VBAT voltage rating, some protection

should be reserved to prevent the damage by voltage surge. It is a good way to add a 5.1V zener diode to protect the IC against low frequency voltage surge. The zener diode's total dissipation should be more than 1Watt. It should place the component close to the U10 connector.

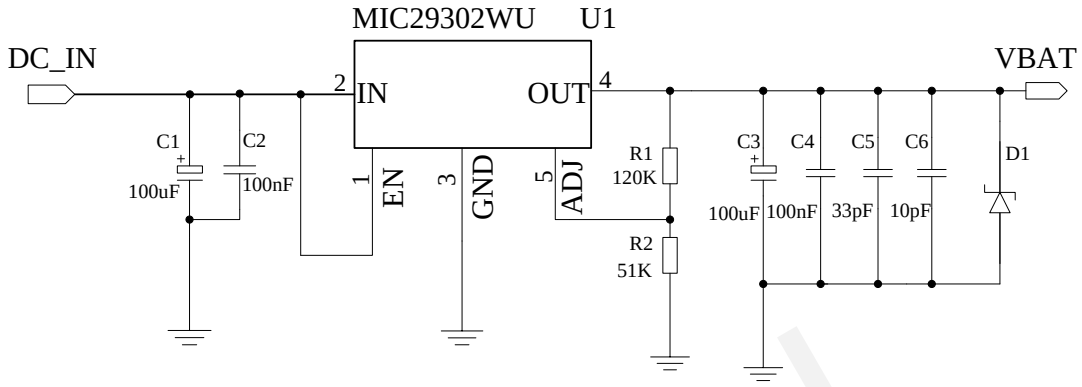


Figure 5: Reference circuit of the power supply input

3.3.5. Monitor power supply

To monitor the supply voltage, you can use the 'AT+CBC' command which includes three parameters: charging status, remaining battery capacity and voltage value (in mV). It returns the 0-100 percent of battery capacity and actual value measured between VBAT and GND. The voltage is continuously measured at an interval depending on the operation mode. The displayed voltage (in mV) is averaged over the last measuring period before the "AT+CBC" command is executed.

For more details, please refer to ***document [1].***

3.4. Power up and down scenarios

3.4.1. Power on

The module can be turned on by the PWRKEY pin, which are described in following chapters 3.4.1.1

Note: The module is set to autobauding mode (AT+IPR=0) in default configuration. In the autobauding mode, the URC 'RDY' after powering on is not sent to host controller. AT command can be sent to the module 2-3 seconds after the module is powered on. Host controller should firstly send an 'AT' or 'at' string in order that the module can detect baud rate of host controller, and it should send the second or the third 'AT' or 'at' string until receiving 'OK' string from the module. Then an 'AT+IPR=x;&W' should be sent to set a fixed baud rate for the module and save the configuration to flash memory of the module. After these configurations, the URC 'RDY' would be received from the UART Port of the module every time when the

module is powered on. Refer to section 'AT+IPR' in document [1].

3.4.1.1. Power on module using the PWRKEY pin

Customer's applications can turn on the module by driving the PWRKEY pin to a low level voltage and after STATUS pin outputs a high level, PWRKEY pin can be released. Customer may monitor the level of the STATUS pin to judge whether the module is power-on or not. An open collector driver circuit is suggested to control the PWRKEY. A simple reference circuit is illustrated in Figure 6.

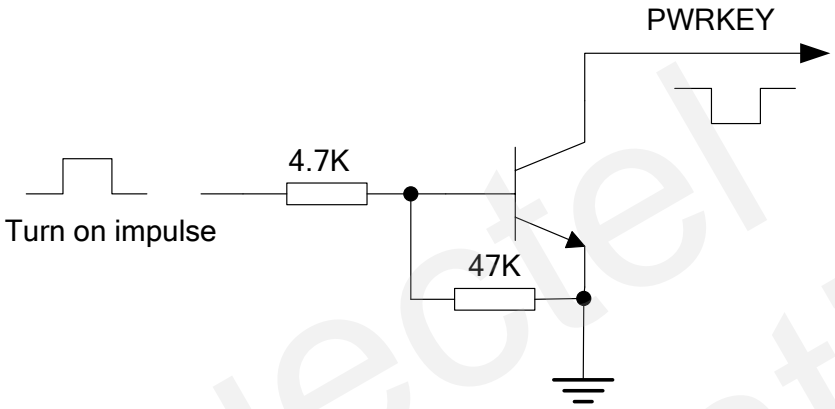


Figure 6: Turn on the module using driving circuit

The other way to control the PWRKEY is using a button directly. A TVS component is indispensable to be placed nearby the button for ESD protection. When pressing the key, electrostatic strike may generate from finger. A reference circuit is showed in Figure 7.

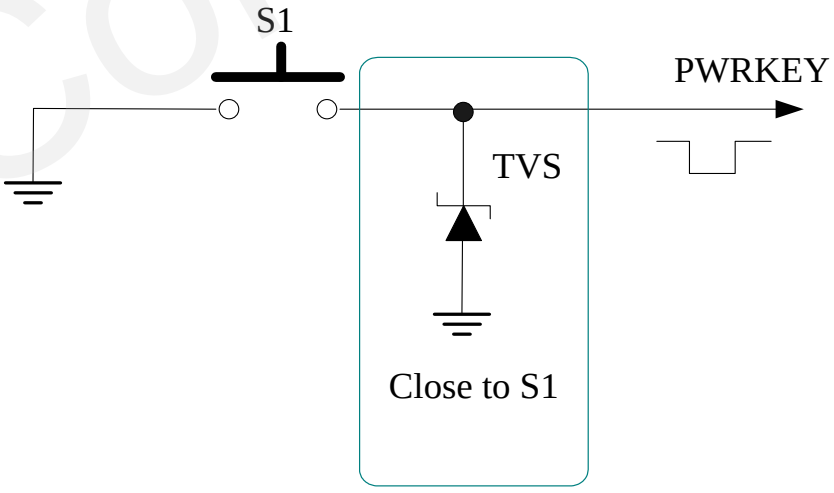


Figure 7: Turn on the module using keystroke

The power on scenarios is illustrated as following figure.

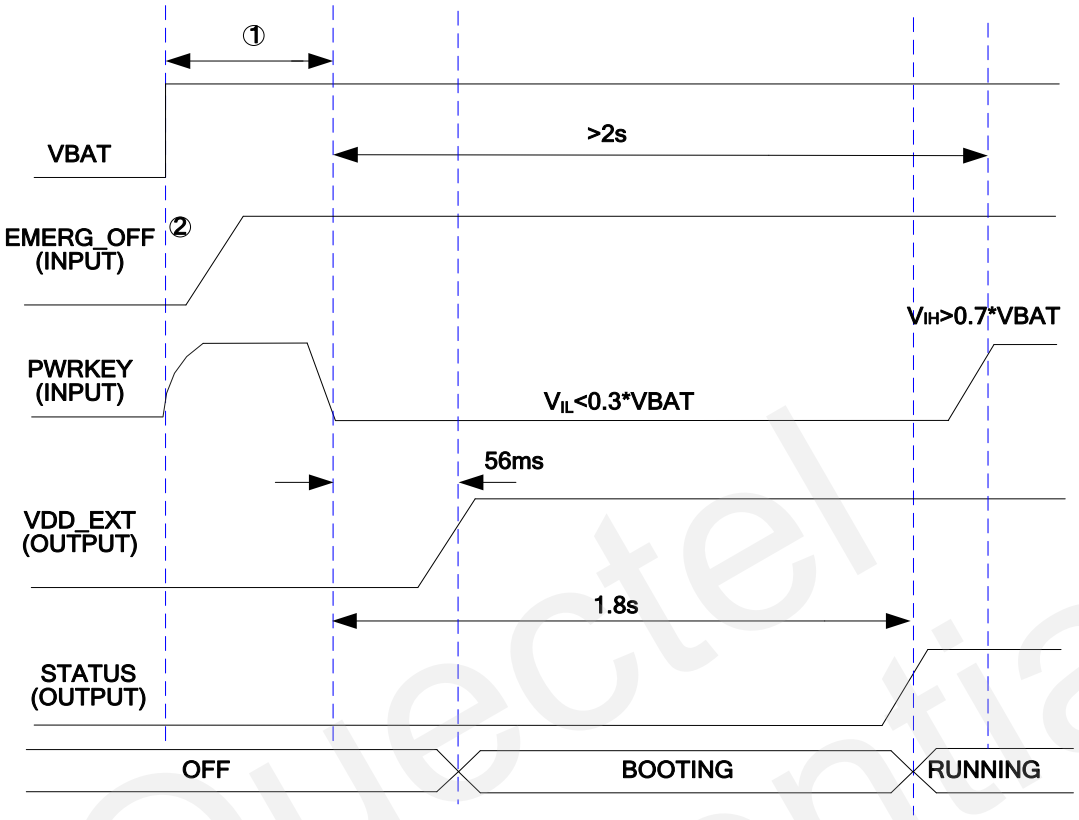


Figure 8: Timing of turning on system

① ***Make sure that VBAT is stable before pulling down PWRKEY pin. The time between them is recommended 100ms.***

② ***Customer can keep the EMERG_OFF pin unconnected or pull high before the power on procedure.***

Note: Customer can monitor the voltage level of the STATUS pin to judge whether the module is power-on. After the STATUS pin goes to high level, PWRKEY may be released. If the STATUS pin is ignored, pull the PWRKEY pin to low level for more than 2 seconds to turn on the module.

3.4.2. Power down module

The following procedures can be used to turn off the module:

- Normal power down procedure: Turn off module using the PWRKEY pin
- Normal power down procedure: Turn off module using command "AT+QPOWD=1"
- Emergent power down procedure: Turn off module using the EMERG_OFF pin

3.4.2.1. Power down module using the PWRKEY pin

Customer's application can turn off the module by driving the PWRKEY to a low level voltage for certain time. The power-down scenario is illustrated in Figure 9.

The power-down procedure causes the module to log off from the network and allows the software to save important data before completely disconnecting the power supply, thus it is a safe way.

Before the completion of the power-down procedure the module sends out the result code shown below:

NORMAL POWER DOWN

Note: This result code does not appear when autobauding is active and DTE and DCE are not correctly synchronized after start-up. The module is recommended to set a fixed baud rate.

After that moment, no further AT command can be executed and then the module enters the POWER DOWN mode, only the RTC is still active. The POWER DOWN mode can also be indicated by the STATUS pin, which is a low level voltage in this mode.

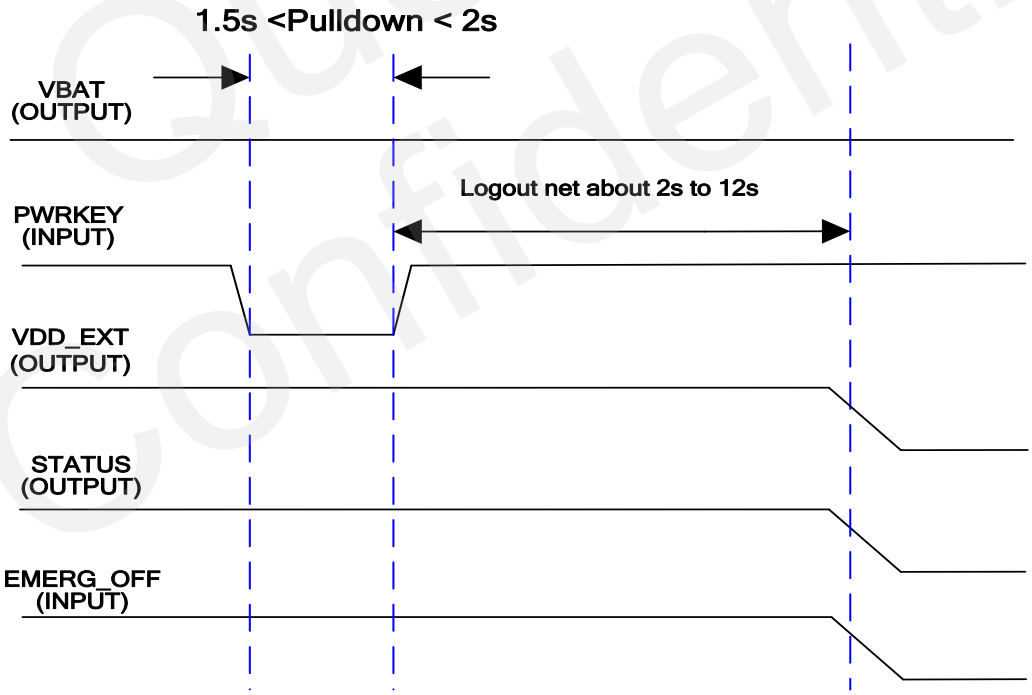


Figure 9: Timing of turning off the module

3.4.2.2. Power down module using AT command

Customer's application can use an AT command "AT+QPOWD=1" to turn off the module. This command will let the module log off from the network and allow the software to save important data before completely disconnecting the power supply, thus it is a safe way.

Before the completion of the power-down procedure the module sends out the result code shown below:

NORMAL POWER DOWN

After that moment, no further AT command can be executed and then the module enters the POWER DOWN mode, only the RTC is still active. The POWER DOWN mode can also be indicated by STATUS pin, which is a low level voltage in this mode.

Please refer to ***document [1]*** for details about the AT command of "AT+QPOWD".

3.4.2.3. Emergency shutdown using EMERG_OFF pin

The module can be shut down by driving the pin EMERG_OFF to a low level voltage for over 20ms. The EMERG_OFF can be driven by an Open Drain/Collector driver or a button. The circuit is illustrated as the following figures.

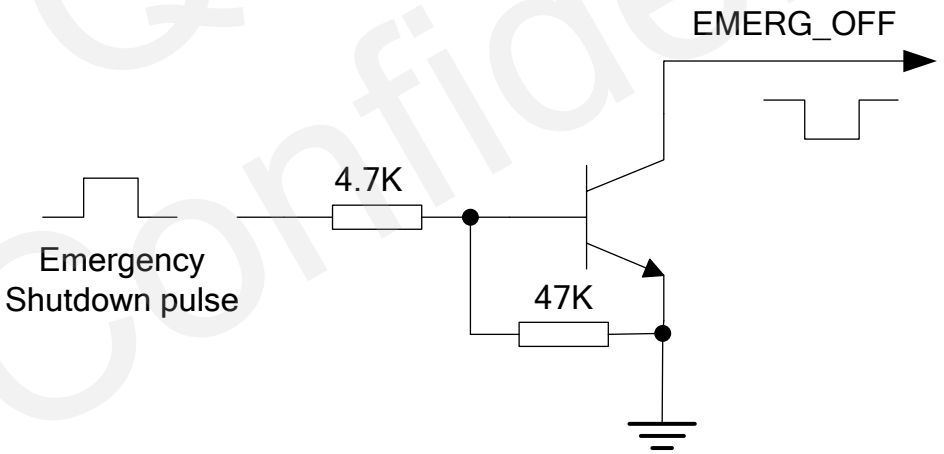


Figure 10: Reference circuit for EMERG_OFF by using driving circuit

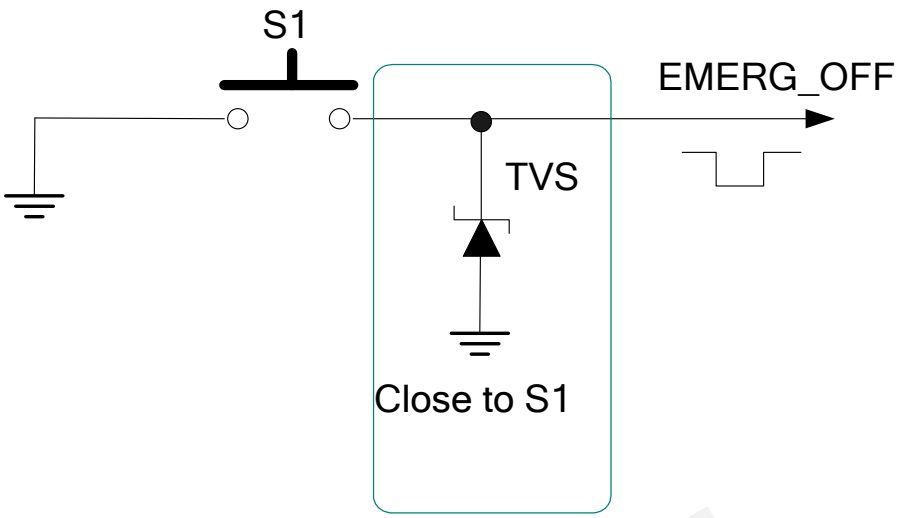


Figure 11: Reference circuit for EMERG_OFF by using button

3.4.3. Restart module using the PWRKEY pin

Customer's application can restart the module by driving the PWRKEY to a low level voltage for certain time, which is similar to the way to turn on the module. Before restarting the module, at least 500ms should be delayed after detecting the low level of STATUS. The restart scenario is illustrated as the following figure.

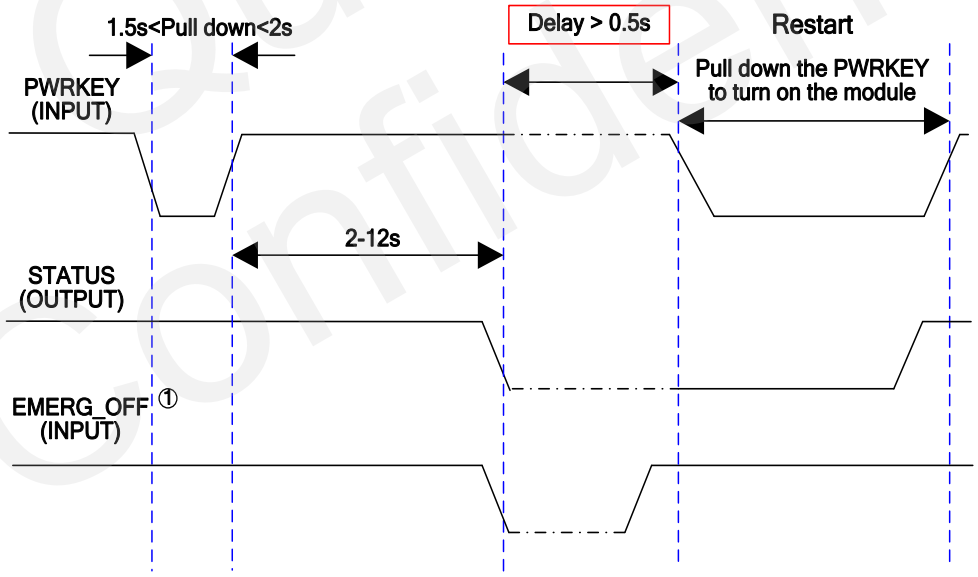


Figure 12: Timing of restarting the system

① ***Customer can keep the EMERG_OFF pin unconnected or pull high before the power on procedure.***

The module can also be restarted by the PWRKEY after emergency shutdown.

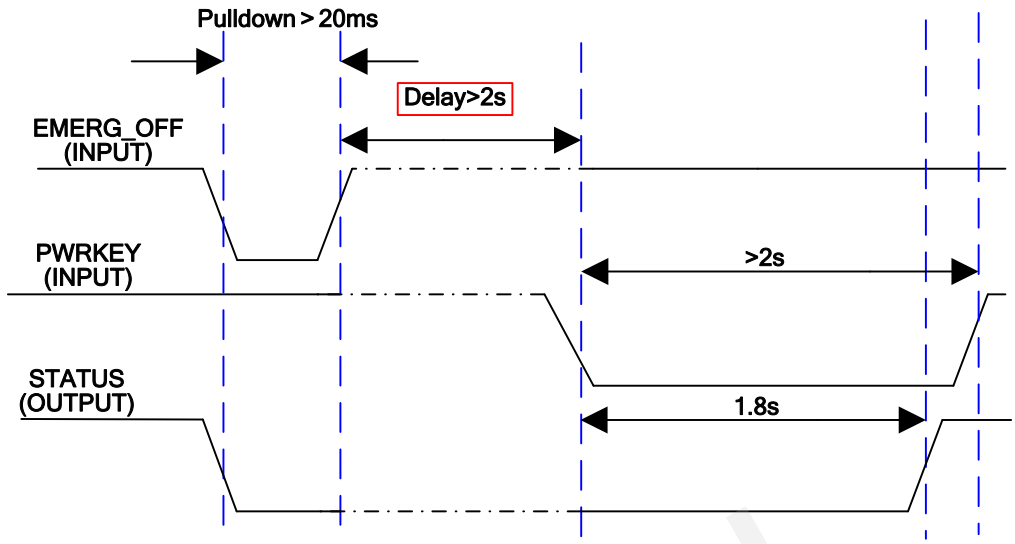


Figure 13: Timing of restarting system after emergency shutdown

3.5. Power saving

Upon system requirement, there are several actions to drive the module to enter low current consumption status. For example, "AT+CFUN" can be used to set module into minimum functionality mode and DTR hardware interface signal can be used to lead system to SLEEP mode.

3.5.1. Minimum functionality mode

Minimum functionality mode reduces the functionality of the module to a minimum level, thus minimize the current consumption when the slow clock mode is activated at the same time. This mode is set with the "AT+CFUN" command which provides the choice of the functionality levels <fun>=0，1，4.

- 0: minimum functionality
- 1: full functionality (default)
- 4: disable both transmitting and receiving of RF part

If the module is set to minimum functionality by "AT+CFUN=0", the RF function and SIM card function would be disabled. In this case, the serial port is still accessible, but all AT commands correlative with RF function or SIM card function will not be accessible.

If the module has been set by "AT+CFUN=4", the RF function will be disabled but the serial port is still active. In this case, all AT commands correlative with RF function will not be accessible.

After the module is set by "AT+CFUN=0" or "AT+CFUN=4", it can return to full functionality by

"AT+CFUN=1".

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

3.5.2. SLEEP mode

The SLEEP mode is disabled in default software configuration. Customer's application can enable this mode by "AT+QSCLK=1". On the other hand, the default setting is "AT+QSCLK=0" and in this mode, the module can not enter SLEEP mode.

When "AT+QSCLK=1" is sent to the module, customer's application can control the module to enter or exit from the SLEEP mode through pin DTR. When DTR is set to high level and there is no on-air or hardware interrupt such as GPIO interrupt or data on UART port, the module will enter SLEEP mode automatically. In this mode, the module can still receive voice, SMS or paging from network but the UART port is not accessible.

Note: Currently, U10 can enter sleep mode only when the module is in UART Mode. For more details about UART Mode, please refer to Table 22.

3.5.3. Wake up module from SLEEP mode

When the module is in the SLEEP mode, the following methods can wake up the module.

- If the DTR Pin is pulled down to a low level, it would wake up the module from the SLEEP mode. The UART port will be active about 20ms after DTR is changed to low level.
- Receiving a voice or data call from network can wake up the module.
- Receiving an SMS from network can wake up the module.

Note: DTR pin should be held low level during communicating between the module and DTE.

3.6. RTC backup

The RTC (Real Time Clock) can be supplied by an external capacitor or battery (rechargeable or non-chargeable) through the pin VRTC. A 1K resistor has been integrated in the module for current limiting. A coin-cell battery or a Large-capacitance Capacitor can be used to backup power supply for RTC.

The following figures show various sample circuits for RTC backup.

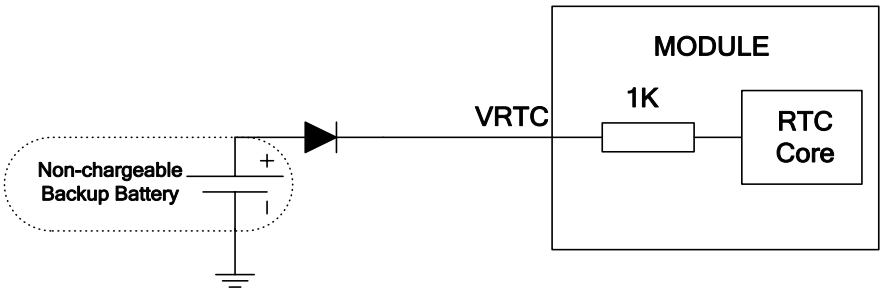


Figure 14: RTC supply from non-chargeable battery

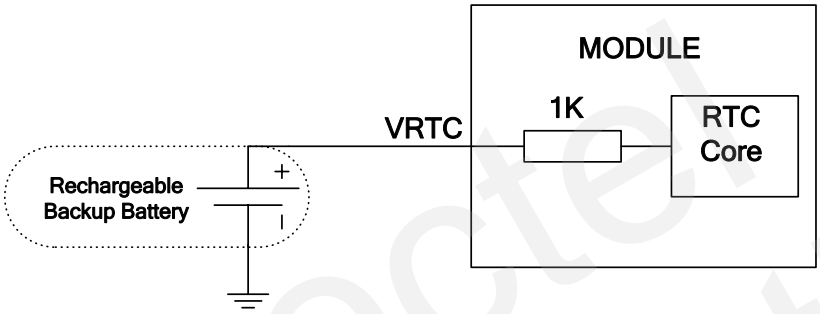


Figure 15: RTC supply from rechargeable battery

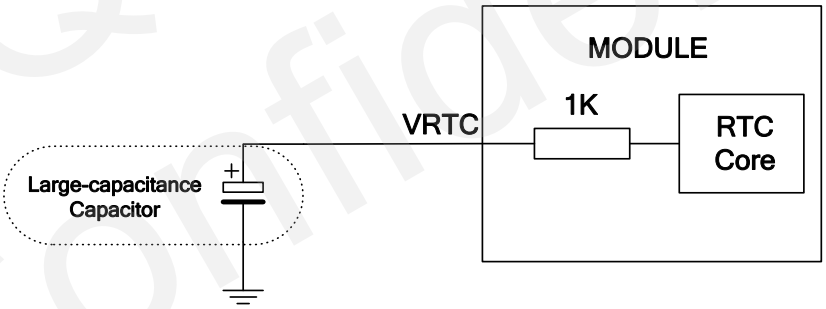


Figure 16: RTC supply from capacitor

Coin-type rechargeable battery such as XH414H-IV01E from Seiko can be used.

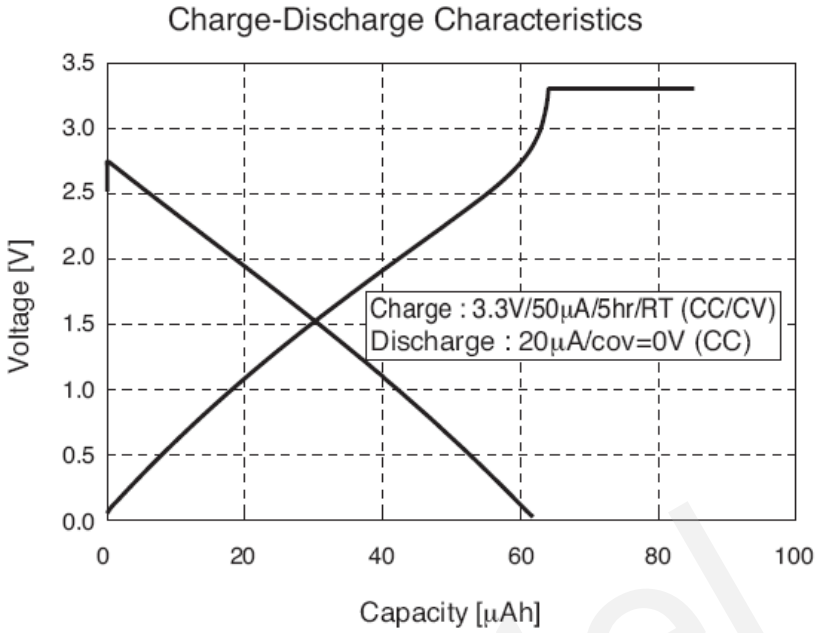


Figure 17: Seiko XH414H-IV01E Charge Characteristic

3.7. UART interfaces

The module provides three UART ports: Main UART Port, Debug UART Port and Auxiliary UART Port. The Main UART Port can work in full function mode while the Debug UART is used for software debugging and Auxiliary UART is used for AT command only. The module is designed as the DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The following tables show the pin definition of these three UART ports.

Table 10: Pin definition of the Main UART Port

Pin Name	Pin No.	Function
RI	19	Ring indicator (when the call, SMS, data of the module are coming, the module will output signal to inform DTE)
DTR	27	Data terminal ready. This pin also can be used for waking the module up
CTS	82	Clear to send
RXD	84	Receive data from TXD of DTE
DCD	85	Data carrier detection (the validity of this pin demonstrates the communication link is set up)
RTS/PCM_CLK	86	Request to send
TXD	88	Send data to RXD of DTE

The module disables the hardware flow control by default. When hardware flow control is required, RTS and CTS should be connected to the host. AT command "AT+IFC=2,2" is used to enable hardware flow control. AT command "AT+IFC=0,0" is used to disable the hardware flow control. For more details, please refer to document [1].

Table 11: Pin definition of the Debug UART Port

Pin Name	Pin NO.	Function
DBG_RXD	76	Receive data of the debug port
DBG_TXD	78	Transmit data of the debug port

Table 12: Pin definition of the Auxiliary UART Port

Pin Name	Pin NO.	Function
AUX_ TXD/PCM_SYNC	79	Send data to the RXD of DTE
AUX_ RXD/PCM_IN	81	Receive data from the TXD of DTE

The logic levels are described in the following table.

Table 13: Logic levels of the UART interface

Parameter	Min	Max	Unit
V_{IL}	-0.3	0.25*VDD_EXT	V
V_{IH}	0.75*VDD_EXT	VDD_EXT +0.3	V
V_{OL}	GND	0.15*VDD_EXT	V
V_{OH}	0.85*VDD_EXT	VDD_EXT	V

3.7.1. Main UART Port

3.7.1.1. The features of Main UART Port.

- Seven lines on Main UART Port. Contain data lines TXD and RXD, hardware flow control lines RTS and CTS, other control lines DTR, DCD and RI.
- Used for AT command and data transfer.
- Support the communication baud rates as follow: 300,600,1200,2400,4800,9600,14400,19200,28800,38400,57600,115200,230400,460800,921600.

- The default setting is autobauding mode. Support the following baud rates for autobauding function:
  4800, 9600, 19200, 38400, 57600, 115200.
- The module disables hardware flow control in default, AT command “AT+IFC=2,2” is used to enable hardware flow control.

After setting a fixed baud rate or Autobauding, please send “AT” string at that rate. The UART port is ready when it responds “OK”.

Autobauding allows the module to detect the baud rate by receiving the string “AT” or “at” from the host or PC automatically, which ensures the module flexibility without considering which baud rate is used by the host controller. Autobauding is enabled by default. To take advantage of the autobauding mode, special attention should be paid according to the following requirements.

Synchronization between DTE and DCE:

When DCE (the module) powers on with the autobauding enabled, it is recommended to wait 2 to 3 seconds before sending the first AT character. After the DTE sending an “AT” or “at” string to the module, the module will detect baud rate of the DTE. It is recommended to send the second or third “AT” or “at” string until the DTE receives the “OK” string from module. After that, DTE and DCE are correctly synchronized.

If the host controller needs URC in the mode of autobauding, it must be synchronized firstly. Otherwise the URC will be discarded.

Restrictions on autobauding operation

- The UART port has to be operated at 8 data bits, no parity and 1 stop bit (factory setting).
- Only the strings “AT” or “at” can be detected (neither “At” nor “aT”).
- The Unsolicited Result Codes like "RDY", "+CFUN: 1" and "+CPIN: READY” will not be indicated when the module is turned on with autobauding enabled and not be synchronized.
- Any other Unsolicited Result Codes will be sent at the previous baud rate before the module detects the new baud rate by receiving the first “AT” or “at” string. The DTE may receive unknown characters after switching to new baud rate.
- It is not recommended to switch to autobauding from a fixed baud rate.

Note: To assure reliable communication and avoid any problems caused by undetermined baud rate between DCE and DTE, it is strongly recommended to configure a fixed baud rate and save it instead of using autobauding after start-up. For more details, please refer to Section “AT+IPR” in document [1].

3.7.1.2. The connection of Main UART Port

The connection between module and host using Main UART Port is very flexible. Three

connection styles are illustrated as below.

Main UART Port connection is shown as below when it is applied in modulation-demodulation.

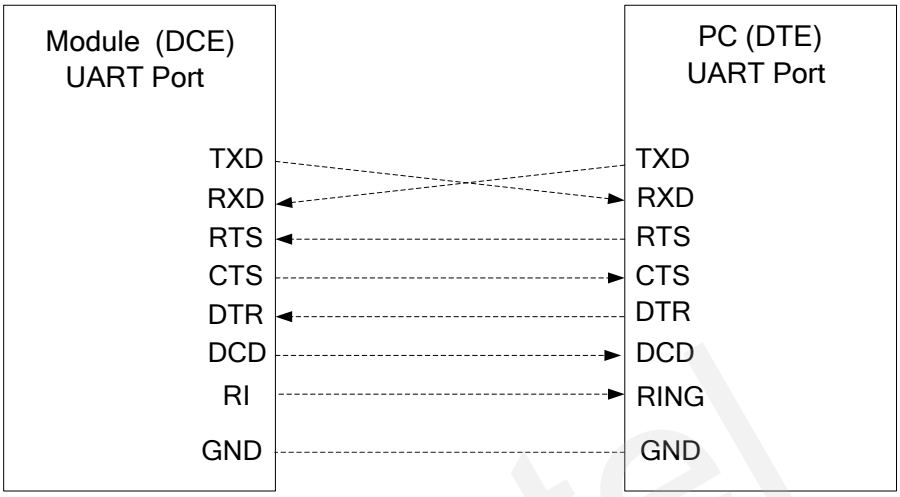


Figure 18: Connection of full function UART port

Three lines connection is shown as below.

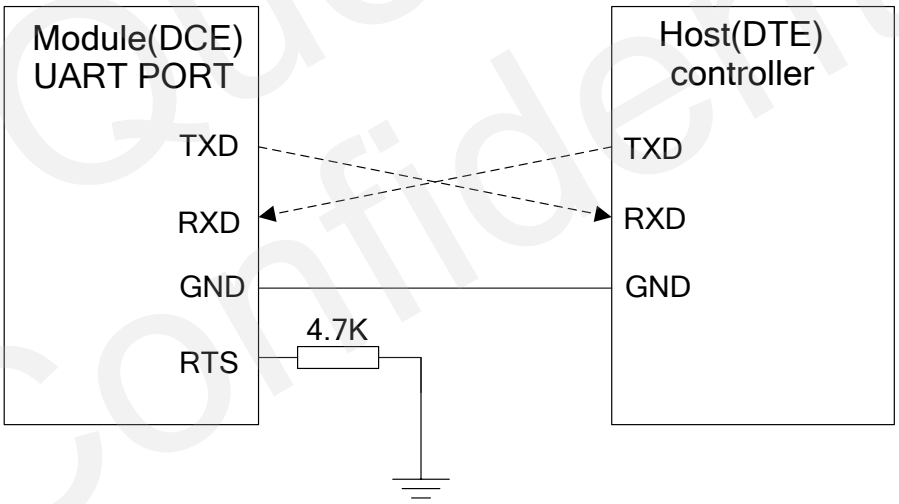


Figure 19: Connection of three lines UART port

Connection with hardware flow control is shown as below. This connection will enhance the reliability of the mass data communication.

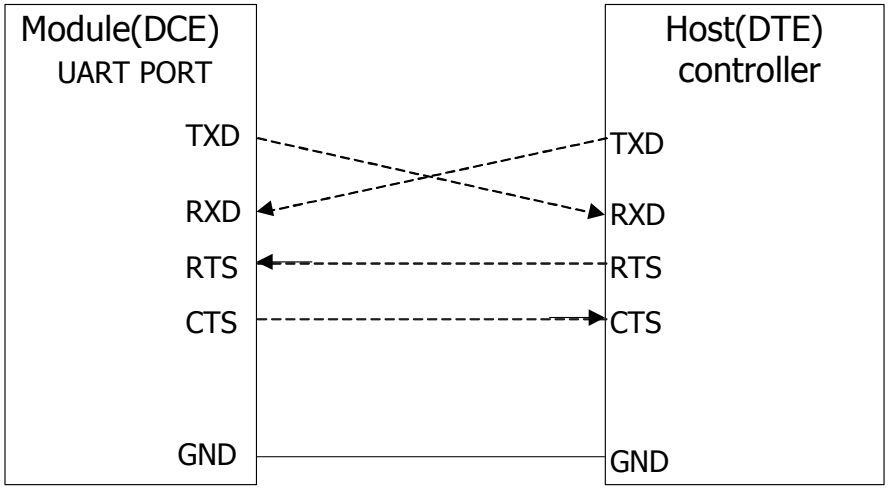


Figure 20: Connection of associated hardware flow control

3.7.1.3. Software upgrade

U10 module can upgrade the software through the Main UART Port. The following figure shows the software upgrade circuit. The PWRKEY pin must be pulled down before the software upgrade.

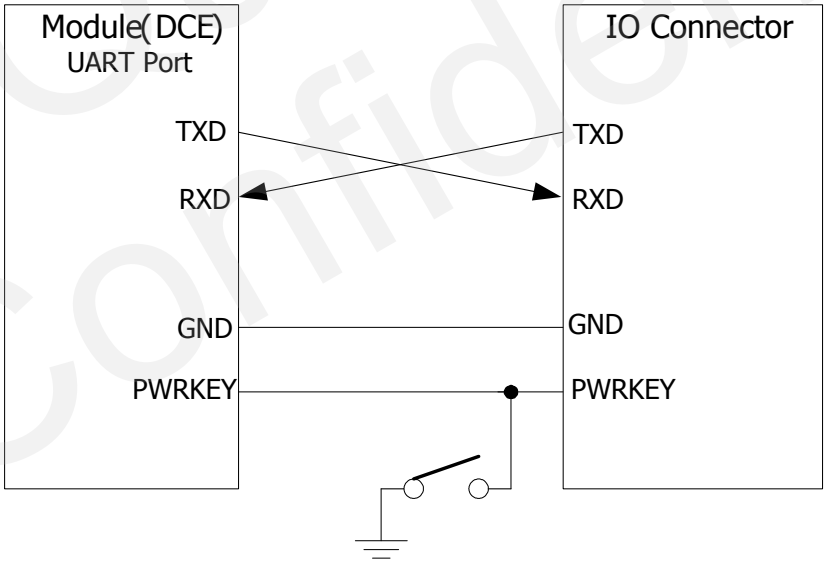


Figure 21: Reference design for software upgrade

3.7.2. Debug Port

Debug Port features:

- Two lines: DBG_TXD and DBG_RXD.

- It outputs log information automatically.
- Debug Port is only used for software debugging and its baud rate must be configured as 460800bps.

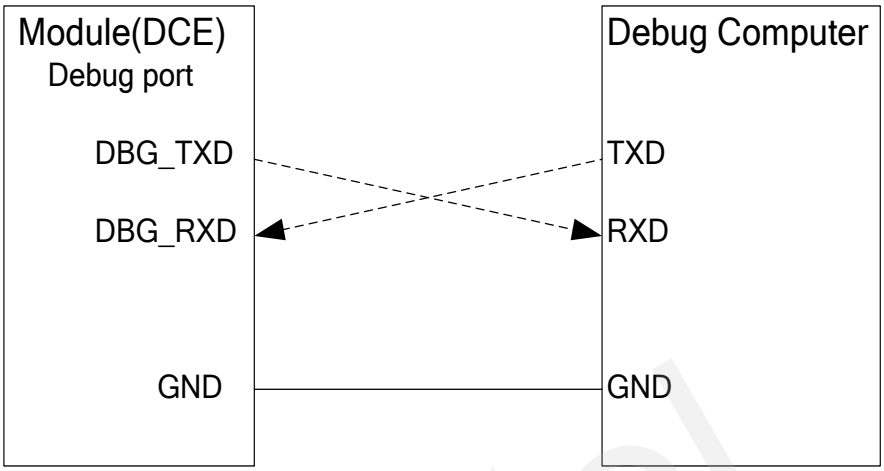


Figure 22: Connection for software debug

3.7.3. Auxiliary Port

Auxiliary Port features:

- Two data lines: AUX _TXD and AUX_ RXD.
- Auxiliary UART Port is used for AT command only. It can not support PS data, voice call, etc.
- Only Support the communication baud rates with 115200 by current software version.

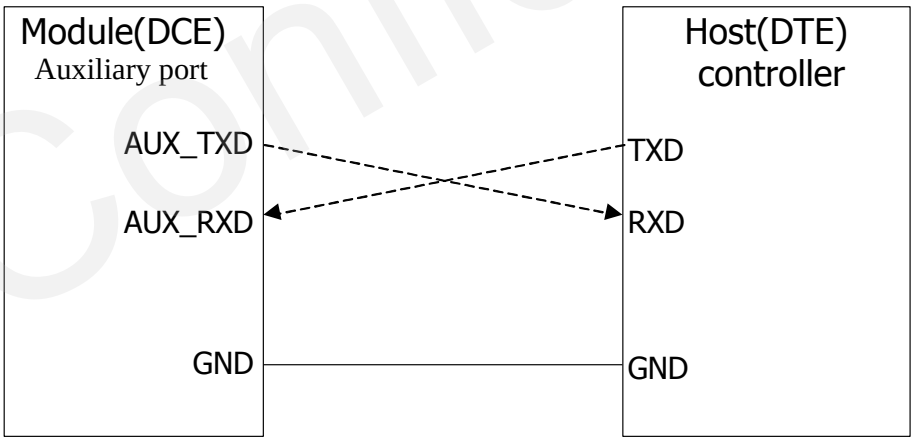


Figure 23: Connection of Auxiliary UART Port

3.7.4. UART Application

The reference design of 3.3V level match is shown as below. If the host termination is 3V system,

please change the resistor from 5.6K to 15K.

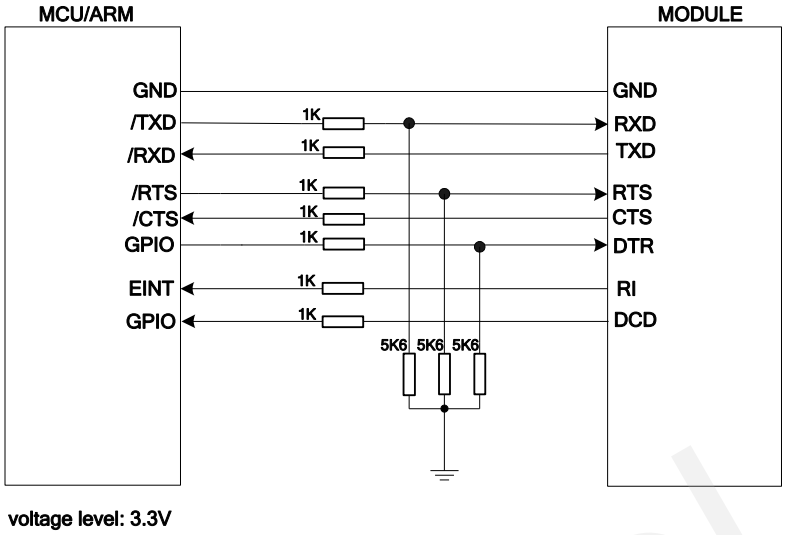


Figure 24: 3.3V level match circuit

The reference design of 5V level match is shown as below. The construction of dotted line can refer to the construction of solid line. Please pay attention to direction of connection. Input dotted line of module should refer to input solid line of the module. Output dotted line of module should refer to output solid line of the module.

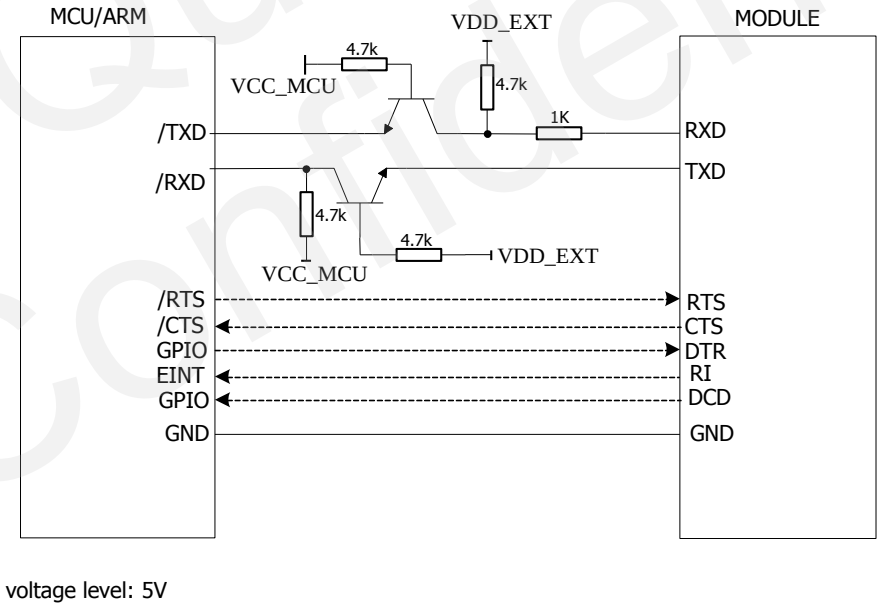


Figure 25: 5V level match circuit

The following picture is an example of connection between module and PC. A RS_232 level shifter IC or circuit must be inserted between module and PC, since these three UART ports do not support the RS_232 level, while support the CMOS level only.

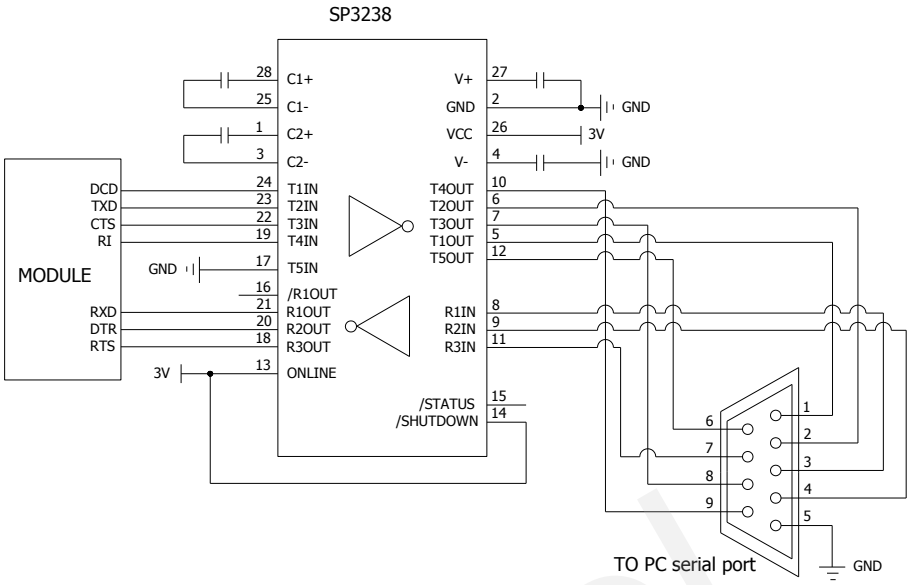


Figure 26: RS232 level converter circuit

3.8. SIM card interface

3.8.1. SIM card application

U10 has two SIM interfaces that support two SIM cards simultaneously. The SIM card interface circuitry meets ETSI and IMT-2000 SIM interface requirements. It can support either 1.8V or 3V SIM card automatically. The main interface supports both USIM and SIM card while the second interface can support SIM card only.

Note: The second SIM card interface is not supported by current software version.

3.8.2. SIM1 card interface

Table 14: Pin definition of the SIM1 interface

Pin Name	Pin NO.	Function
SIM1_VDD	65	Power supply for SIM1 Card. Automatic detection of SIM card voltage. 3.0V ±10% and 1.8V ±10%. Maximum supply current is around 100mA.
SIM1_DATA	67	SIM Card data I/O, pull up via 5K resistor internally
SIM1_CLK	71	SIM Card clock
SIM1_RST	69	SIM Card reset
SIM1_PRESENCE	63	SIM Card detect
SIM1_GND	61	SIM Card ground

The following figure shows the reference design of the 8-pin SIM card.

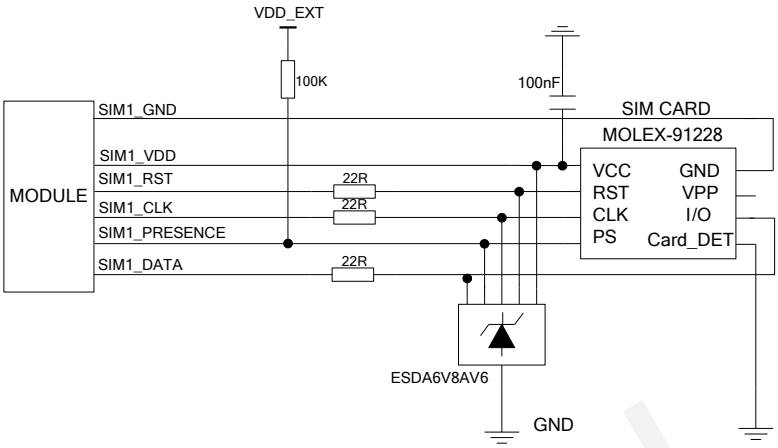


Figure 27: Reference circuit of the 8-pin SIM card

The pin SIM_PRESENCE is used to detect whether the tray of the Molex SIM socket which is used for holding SIM card is present in the card socket. When the tray is inserted in the socket, SIM_PRESENCE is at low level. Regardless of whether the SIM card is in the tray or not, the change of SIM_PRESENCE level from high to low level inspires the module to reinitialize SIM card. In default configuration, SIM card detection function is disabled. Customer's application can use "AT+QSIMDET=1, 0" to switch on and "AT+QSIMDET=0, 0" to switch off the SIM card detection function. For details of this AT command, please refer to ***document [1]***. When "AT+QSIMDET=1, 0" is set and the tray with SIM card is removed from SIM socket, the following URC will be presented.

+CPIN: NOT READY

When the tray with SIM card is inserted into SIM socket again and the module finishes re-initializing SIM card, the following URC will be presented:

Call Ready

If customer does not need the SIM card detection function, keep SIM1_PRESENCE open. The reference circuit for using a 6-pin SIM card socket is illustrated as the following figure.

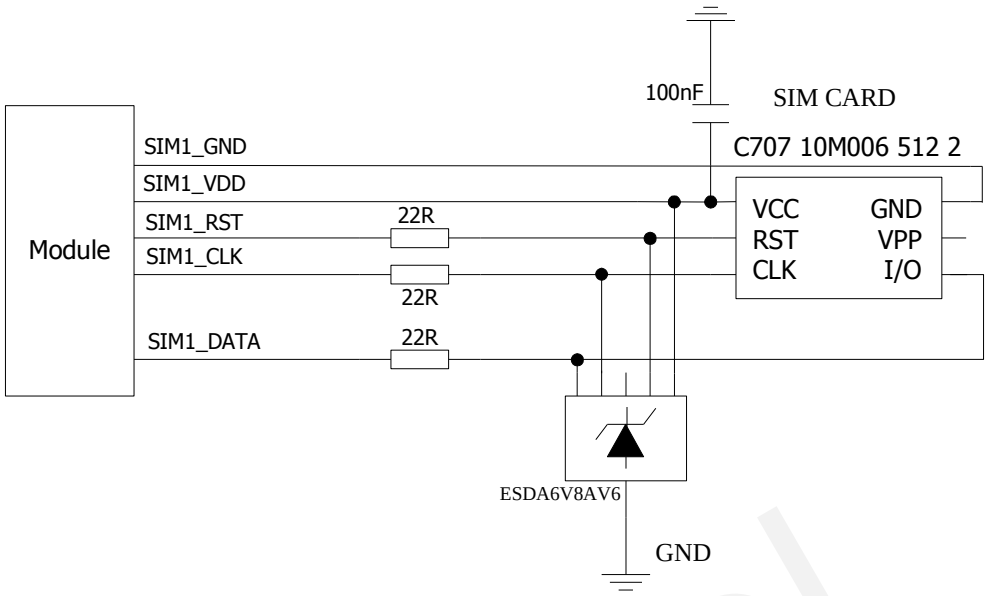


Figure 28: Reference circuit of the 6 pins SIM card

In order to enhance the reliability and availability of the SIM card in the customer's application, please follow the criterion in the SIM circuit design below.

- Keep layout of SIM card as close as possible to the module. Assure the possibility of the length of the trace is less than 20cm.
- Keep SIM card signal away from RF and VBAT alignment.
- Assure the ground between module and SIM cassette short and wide. Keep the width of ground no less than 0.5mm to maintain the same electric potential. The decouple capacitor of SIM_VDD is less than 1uF and must be near to SIM cassette.
- To avoid cross talk between SIM1_DATA and SIM1_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 TVS such as WILL (http://www.willsemi.com) ESDA6V8AV6. The 22Ω resistors should be added in series between the module and the SIM card so as to suppress the EMI spurious transmission and enhance the ESD protection. Please to be noted that the SIM peripheral circuit should be close to the SIM card socket.

3.8.3. 8 Pin SIM Card holder

For 8-pin SIM card holder, it is recommended to use Molex 91228. Please visit http://www.molex.com for more information.

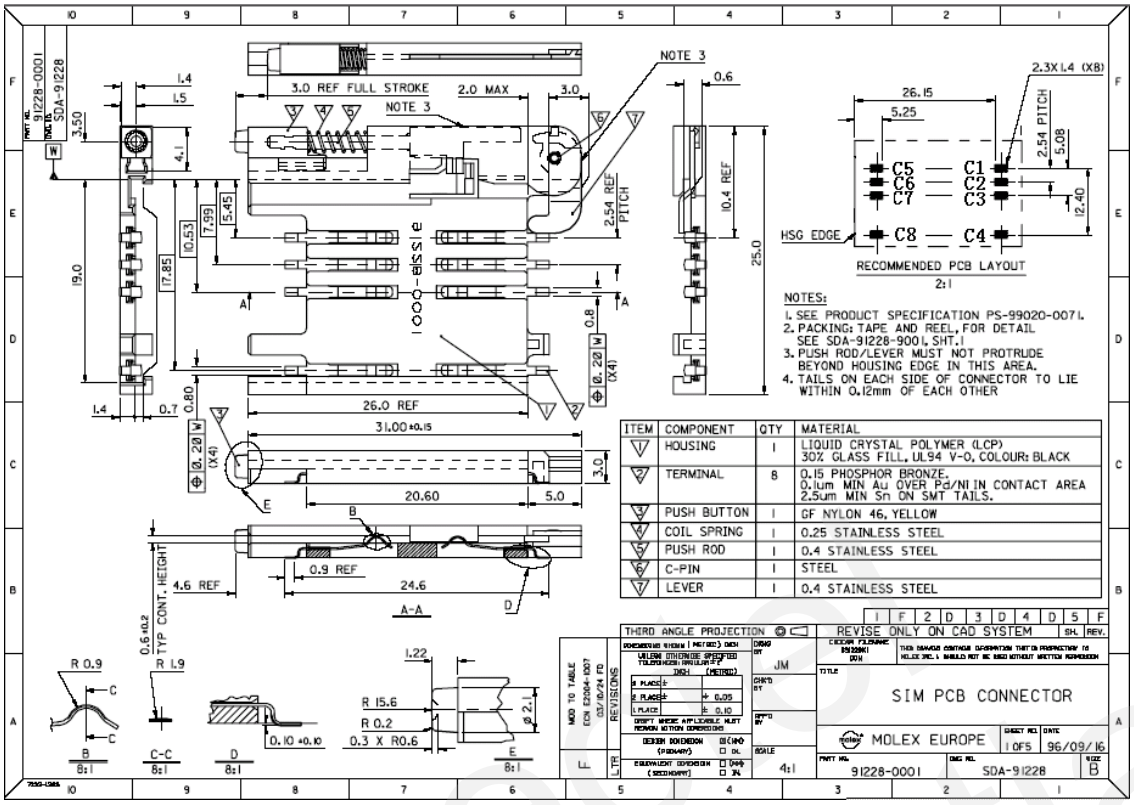


Figure 29: Molex 91228 SIM card holder

Table 15: Pin description of Molex SIM card holder

Pin Name	Pin NO.	Function
SIM_VDD	C1	SIM Card Power supply
SIM_RST	C2	SIM Card Reset
SIM_CLK	C3	SIM Card Clock
SIM_PRESENCE	C4	SIM Card Presence Detection
GND	C5	Ground
VPP	C6	Not Connect
SIM_DATA	C7	SIM Card Data I/O
SIM_DETECT	C8	Pulling down GND with external circuit. When the tray is present, C4 is connected to C8.

3.8.4. 6 Pin SIM holder

For 6-pin SIM card holder, it is recommended to use Amphenol C707 10M006 512 2. Please visit http://www.amphenol.com for more information.

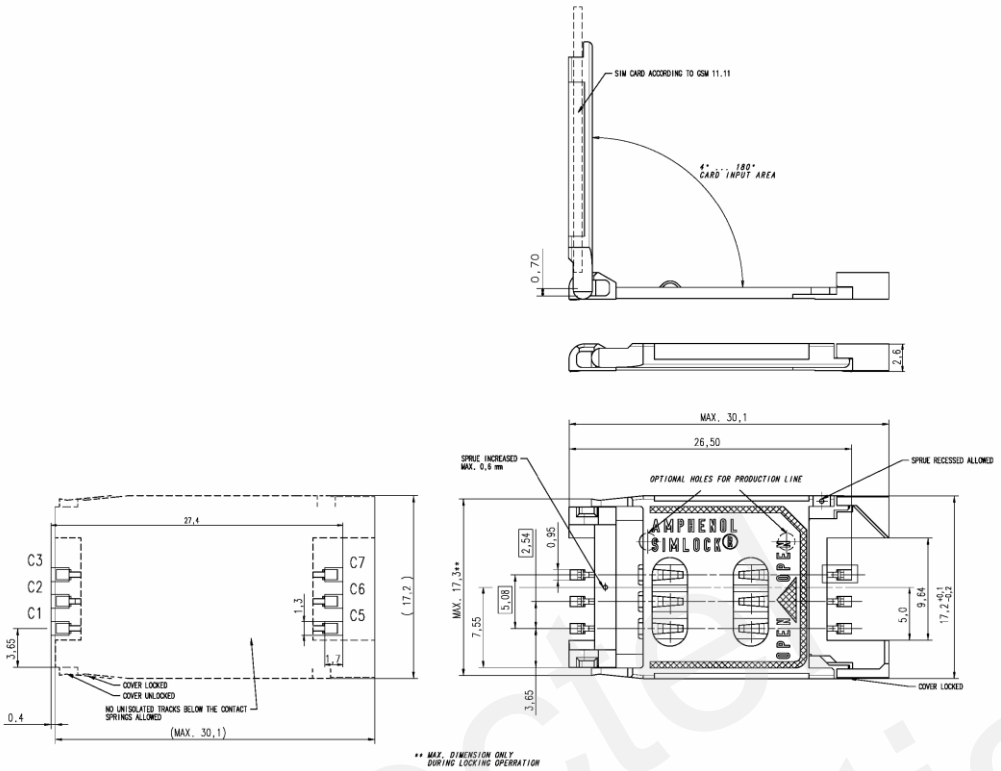


Figure 30: Amphenol C707 10M006 512 2 SIM card holder

Table 16: Pin description of Amphenol SIM card holder

Pin Name	Pin NO.	Function
SIM_VDD	C1	SIM Card Power supply
SIM_RST	C2	SIM Card Reset
SIM_CLK	C3	SIM Card Clock
GND	C5	Ground
VPP	C6	Not Connect
SIM_DATA	C7	SIM Card data I/O

3.9. Audio interfaces

The module provides two analogue audio input channels and two analogue audio output channels.

Table 17: Pin definition of Audio interface

Interface	Pin Name	Pin NO.	Function
AIN1/AOUT1	MIC1P	11	Positive input of audio channel one
	MIC1N	13	Negative input of audio channel one
	SPK1P	15	Positive output of audio channel one
	SPK1N	17	Negative output of audio channel one
AIN2/AOUT2	MIC2N	3	Negative input of audio channel two
	MIC2P	5	Positive input of audio channel two
	SPK2R	7	Right channel of stereo audio output
	SPK2L	9	Left channel of stereo audio output
Audio GND	AGND	1	Dedicated GND for Audio

AIN1 and AIN2 can be used for both microphone and line inputs with internal bias voltage. An electret microphone is usually used. Both AIN1 and AIN2 are differential input channels.

AOUT1 is a differential output channel. It is usually used for both receiver and speaker outputs

AOUT2 is typically used for earphone or speaker. It is a stereo channel. SPK2L is the left channel and SPK2R is the right channel. If customer needs to play Melody or Midi ring tone for incoming call, AOUT2 is the only channel that can be used. If a speaker (typ. 8ohm) is to be driven, an audio amplifier should be employed.

These two audio channels can be swapped by "AT+QAUDCH" command. Use AT command "AT+QAUDCH" to select audio channel:

- 0--AIN1/AOUT1, the default value is 0.
- 1--AIN2/AOUT2.

For more details, please refer to ***document [1].***

For each channel, customer can use "AT+QMIC" to adjust the input gain level of microphone. Customer can also use "AT+CLVL" to adjust the output gain level of receiver and speaker. "AT+QECHO" is used to set the parameters for echo cancellation control. "AT+QSIDET" is used to set the side-tone gain level. For more details, please refer to ***document [1].***

3.9.1. Decrease TDD noise and other noise

The 33pF (0603 package) capacitor is applied for filtering out 900MHz RF interference when the module is transmitting at GSM900MHz. Without placing this capacitor, TDD noise could be heard. Moreover, the 10pF (0603 package) capacitor here is for filtering out 1800MHz RF interference. However, the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, customer would have to discuss with their capacitor vendor to choose the most suitable capacitor for filtering out GSM850MHz, GSM900MHz, DCS1800MHz and PCS1900MHz separately.

The severity degree of the RF interference in the voice channel during GSM transmitting period largely depends on the application design. In some cases, GSM900 TDD noise is more severe while in other cases, DCS1800 TDD noise is more obvious. Therefore, customer can have a choice based on test results. Sometimes, even no RF filtering capacitor is required.

The capacitor which is used for filtering out RF noise should be close to RJ11 or other audio interfaces. Audio alignment should be as short as possible.

In order to decrease radio or other signal interference, the position of RF antenna should be kept away from audio interface and audio alignment. Power alignment and audio alignment should not be parallel, and power alignment should be far away from audio alignment.

The differential audio traces have to be placed according to the differential signal layout rule.

3.9.2. Microphone interfaces design

AIN1/AIN2 channels with internal bias supply can be connected to an external electret microphone. A reference circuit is shown in Figure 31.

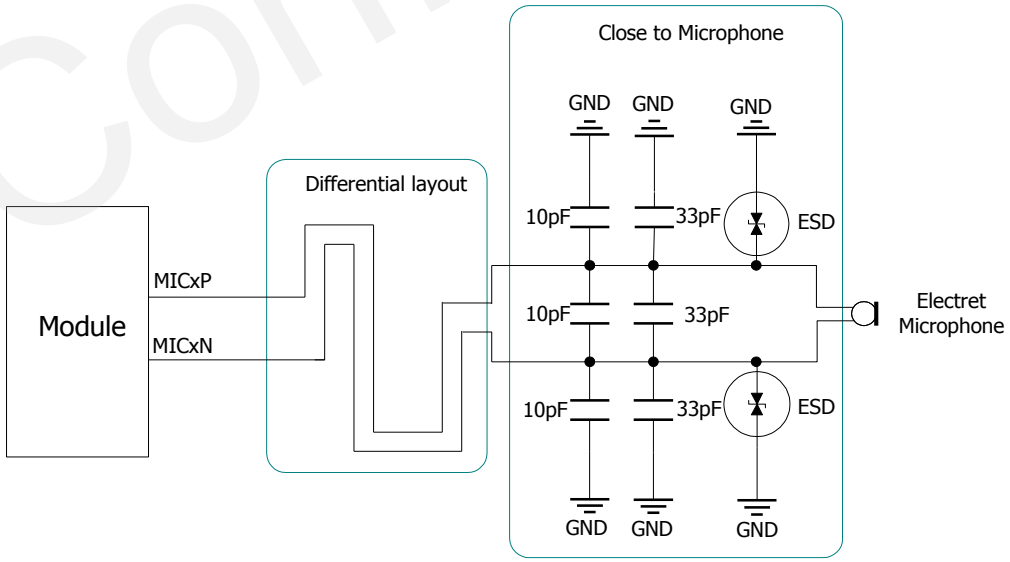


Figure 31: Microphone interface design of AIN1&AIN2

3.9.3. Receiver and speaker interface design

The following figure shows the reference circuit of AOUT1.

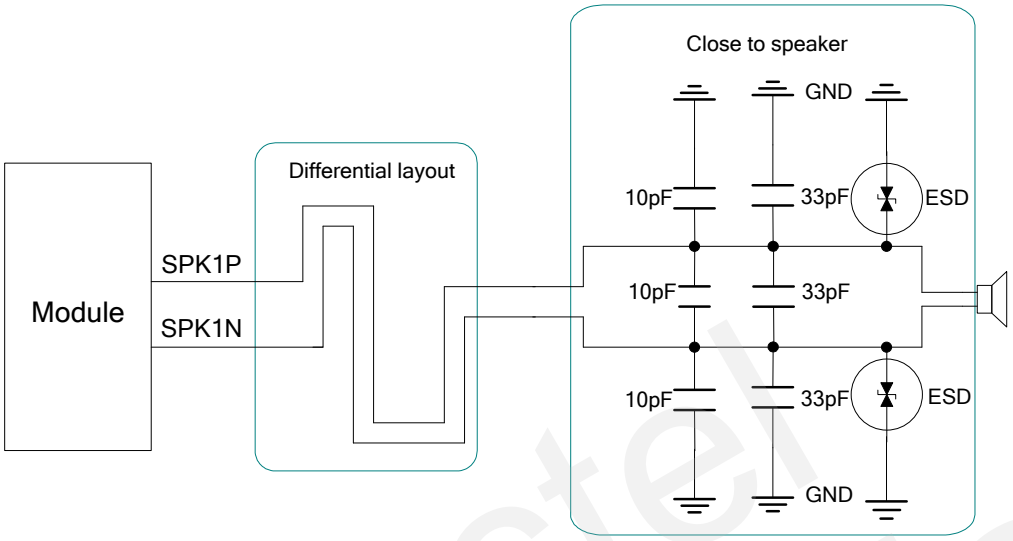


Figure 32: Receiver interface reference design of AOUT1

The AOUT2 is a stereo audio channel. The following figure shows the reference circuit of SPK2L with AGND.

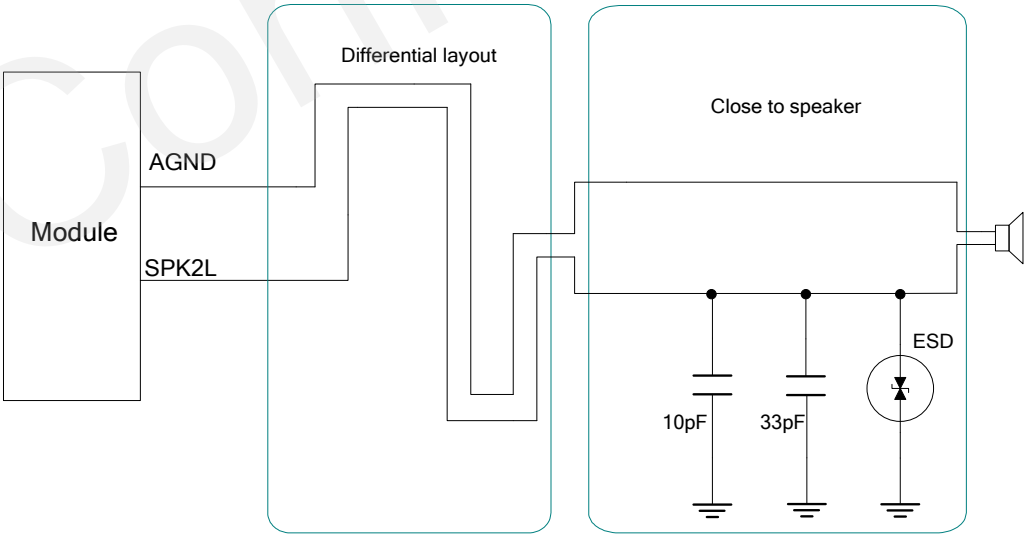


Figure 33: Single side design of AOUT2 with SPK2L

3.9.4. Earphone interface design

The following reference design shows the earphone usage with MIC2N/P and the stereo channel SPK2L/R.

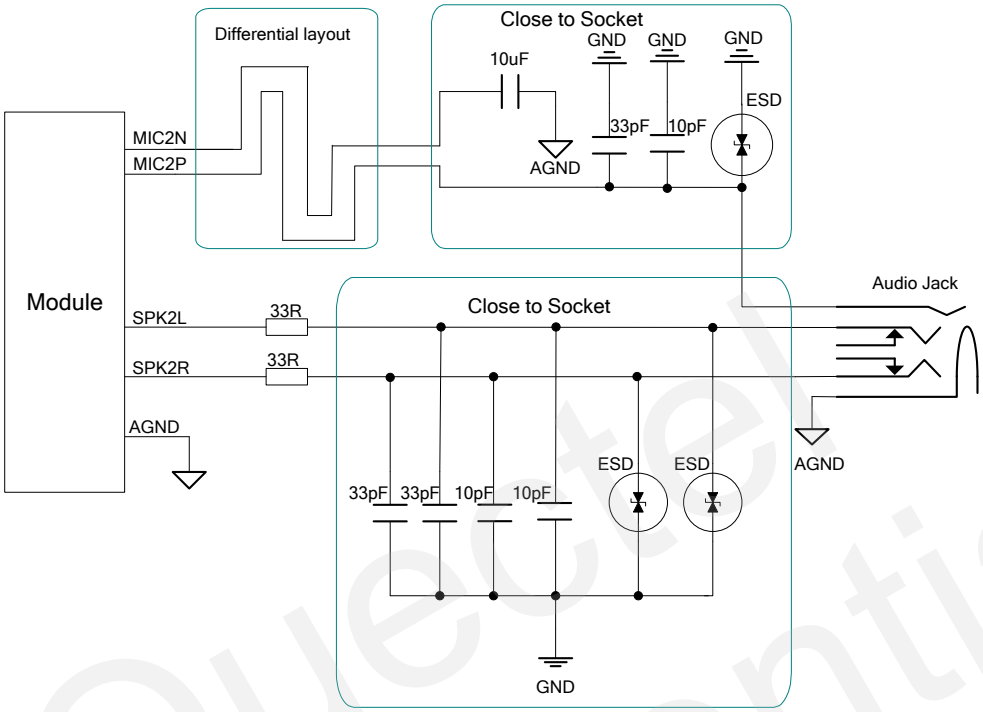


Figure 34: Earphone interface design

In order to ensure good audio performance, the following design principles should be complied with.

- The MIC2P and MIC2N should be routed in differential traces. MIC2N should be connected to AGND through a 10uF capacitor.
- It is recommended to use the filter capacitor to reduce RF frequency interference such as TDD noise.
- It is recommended to use the bidirectional TVS for ESD protection.
- Reserve 33R resistor in SPK2P and SPK2L for reducing noise.
- The trace width of SPK2L and SPK2R should be no less than 6 mils and should be routed in the inner layer with a GND trace between them.

3.9.5. Speaker interface with amplifier design

If customers want to drive a loud speaker, an external Class-AB/D audio amplifier can used. There are plenty of excellent audio amplifiers in the market. ON semiconductor's NCP2823B which is a

cost effective Class-D mono audio power amplifiers is recommended. The following figure is the reference design.

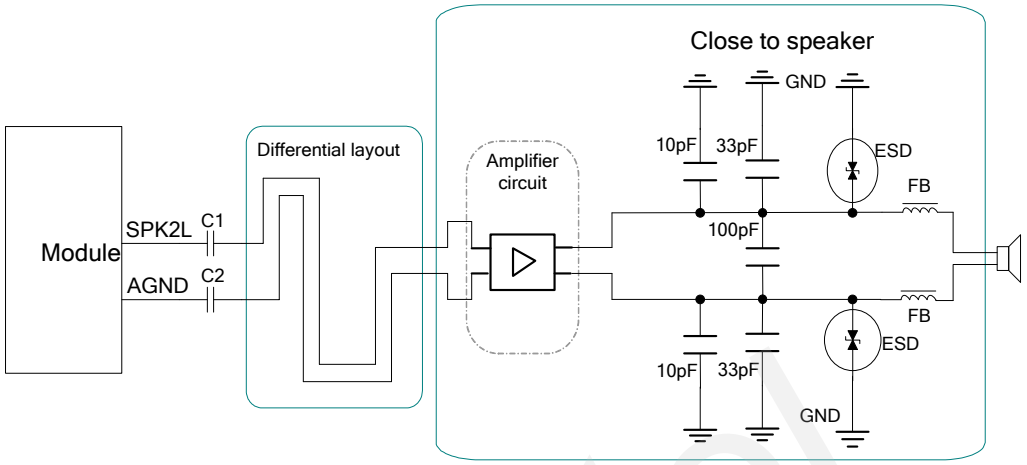


Figure 35: Speaker interface with amplifier design of AOUT2

- The trace width of the audio amplifier output should be greater than 25 mils for 8ohm speaker.
- The trace of the audio amplifier output should be routed differentially and be shielded by GND.
- Reserved two Ferrite beads for amplifier output filtering whose R_{DC}< 0.1ohm and Rated Current >1.0A.
- The SPK2L can be routed with AGND as a pseudo differential mode.
- The value of C1 and C2 depends on the input impedance of audio amplifier.

For more details about NCP2823B, please visit http://www.onsemi.com/.

3.9.6. Audio characteristics

Table 18: Typical electret microphone characteristics

Parameter	Min	Typ	Max	Unit
Working Voltage	1.2	1.5	2.0	V
Working Current	200		500	uA
External Microphone Load Resistance		2.2		k ohm

Table 19: Typical speaker characteristics

Parameter			Min	Typ	Max	Unit
AOUT1	Differential	Load Resistance	28	32		Ohm
AOUT2	Stereo Audio Mode	Load Resistance	16	32		Ohm

3.10. SD Card interface

The module provides a SD Memory Card interface which supports the SD memory Card Specification version 2.0.

The following is the main features of SD card interface.

- Supports 4 bits SD card mode.
- An internal regulator supplies power for SD card. Its default voltage is 3.3V, and driver current is rated to 200mA.
- A clock output and a clock feedback pin provided are used as a clock source. Max clock rate is up to 50 MHz.
- Data rate is compliant with Class 6.
- Support SDHC (Secure Digital High Capacity), up to 32 GB maximum memory card capacity.

Users can store some high-capacity files to external SD memory card, such as the automotive application system. The module can record and store the audio files into the SD card, and play the audio files from SD card as well.

Table 20: Pin definition of the SD card interface

Pin Name	Pin NO.	Description
SD_VDD	49	Power supply for SD card
SD_DATA0	43	Data bit0 of SD card interface
SD_DATA1	41	Data bit1 of SD card interface
SD_DATA2	55	Data bit2 of SD card interface
SD_DATA3	53	Data bit3 of SD card interface
SD_CMD	51	Command pin for SD card
SD_CLK	45	Clock pin for SD card
SD_CLK_FB	47	Clock feedback pin

The following figure shows the reference circuit of SD card interface.

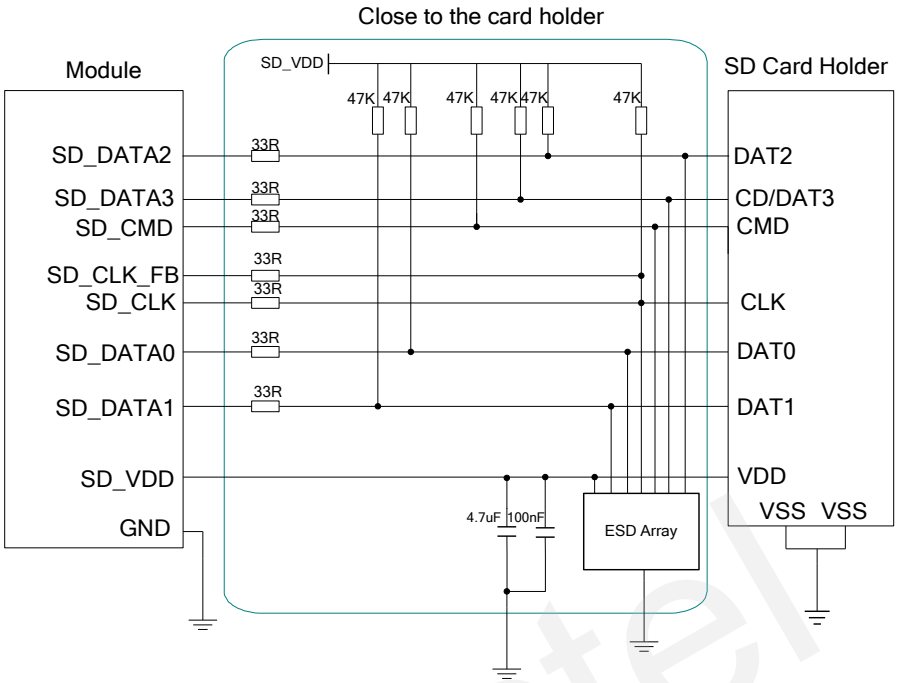


Figure 36: Reference circuit of SD card

In order to ensure good communication performance with SD card, please follow the design rule below:

- Route SD card trace as short as possible.
- To get good ESD performance, some ESD components should be added beside the SD card holder. It is recommended to reserve TVS components to protect the SD card or module from ESD damage, and the parasitic capacitance of the ESD component should be smaller than 15pF.
- All signal lines should be pulled up to SD_VDD.
- SD_CLK_FB should tie together with SD_CLK close to the card holder. SD_CLK and SD_CLK_FB must be grounded on each side to reduce interference.
- All data line, SD_CMD, SD_CLK and SD_CLK_FB should be routed together and the length difference between them must be less than 1000mil.
- Reserve the 33R resistors for improving the signal quality.

3.11. USB interface

The module includes an integrated universal serial bus (USB) transceiver which complies with USB 2.0 standard specifications for high-speed (480Mbps) mode. The following table shows the definition of USB pins.

Table 21: Pin definition of the USB interfaces

Pin Name	Pin NO.	Function	Input Voltage (V)		
			Min	Type	Max
USB_VBUS	64	This pin is used for USB detection.	4.4	5.0	7
USB_DP	59	Plus (+) line of the differential bus, Bi-directional USB signal to/from the peripheral device.	They are compliant with the USB 2.0 specification.		
USB_DM	57	Minus (-) line of the differential bus, Bi-directional USB signal to/from the peripheral device.			
USB_DL	72	USB download control pin for firmware update only. It is high actively.	4.4	5.0	7

More details about the USB 2.0 specifications, please visit http://www.usb.org/home**.**

3.11.1. Typical application

The Features of the USB interface:

- The interface can be mapped to two USB virtual COM ports (USB modem port and USB application port) simultaneously for customer's applications.
- It can be used for upgrading the firmware.
- The USB modem port supports AT command and data transfer.
- The USB application port supports AT command only.

Note: The module only can be used as a USB device currently.

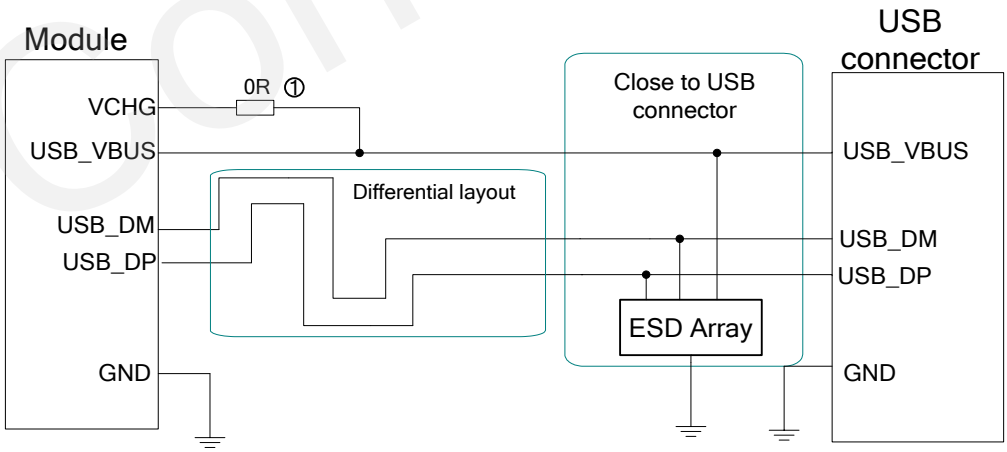


Figure 37: USB reference design

① Please reserve a 0R resistor between VCHG pin and USB_VBUS for current version.

In order to ensure the USB interface design corresponding with USB 2.0 standard, please comply with the following principles.

- It is important to route the USB signal traces as differential pairs. The impedance of USB differential path is 90 ohm.
- Pay attention to the influence of junction capacitance of ESD component on USB data lines. Typically, the capacitance value should be less than 3pF@1MHz.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. It is important to route the USB differential traces in inter-layer with GND shielding not only upper and lower layer but also right and left side.
- Keep the ESD components as closer to the USB connector as possible.

3.11.2. USB upgrade

USB interface supports downloading software cooperated with USB_DL pin. The following figure shows the example of connection.

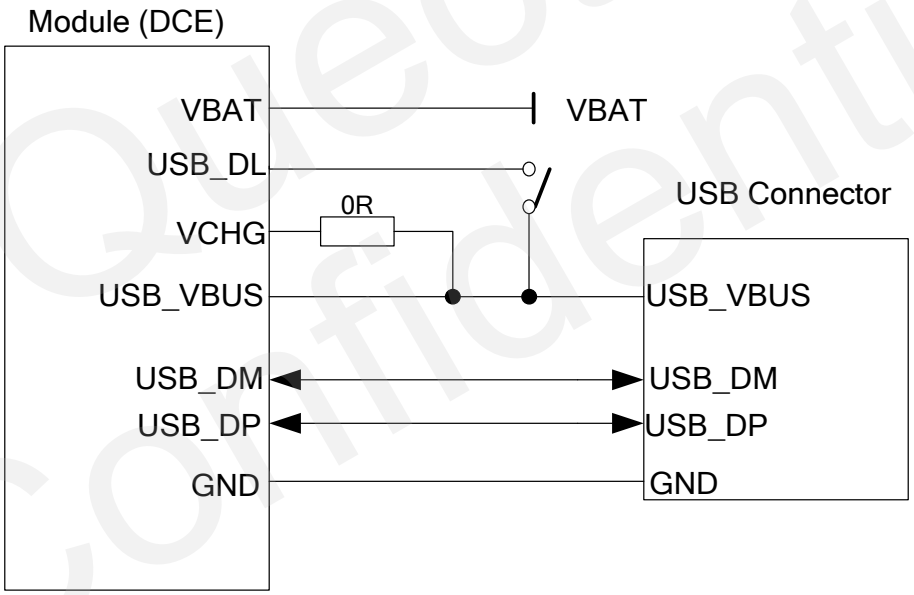


Figure 38: Reference design for USB download

For current version, please reserve the 0R resistor between the VCHG and USB_VBUS.

3.11.3. USB Driver

The module's USB driver supports WinXP, Win7, Linux 2.6, and WinCE 6.0.

3.11.4. UART and USB interface usage

UART Mode is the mode that customer can use the Main UART Port for AT command and data transfer. In this mode, the USB interface is ignored. Customer can not use it even if the physical connection exists.

USB Mode is the mode that customer can use both the Main UART Port and USB interface but the Main UART Port only can be used for AT command while the USB interface can be used for AT command and data transfer.

The following table shows the usage of Main UART Port and USB interface.

Table 22: The UART Mode and USB Mode

Mode	Port	Functions
UART Mode	Main UART Port	Used for AT command and data transfer.
	USB Modem Port	Disabled
	USB Application Port	Disabled
USB Mode	Main UART Port	Used for AT command only.
	USB Modem Port	Used for AT command and data transfer.
	USB Application Port	Used for AT command only.

The module is in the USB Mode by default. When customer wants to use Main UART Port to transmit data, the module should be changed into UART Mode. Customers can use "AT+QPSPORT=0" which can be automatically saved to active the UART Mode after rebooting the module. Customer can also use "AT+QPSPORT=5" to change the mode from UART Mode to USB Mode. The Mode will be active after rebooting.

For more details about "AT+QPSPORT", please refer to the document [1].

3.12. Camera interface

3.12.1. Digital CMOS sensor

The module provides a camera interface for supporting camera, video streaming and video call functions. The interface supports 8 or 10 bit CMOS digital image sensor which can output 8/10 bit Bayer format image data or YUV442 format image data. It supports a resolution up to 3M pixels (YUV sensor) or 5M pixels (JPEG sensor). Built-in hardware-based JPEG CODEC, and FCore4-based MPEG-4 CODEC, H.263 and H.264 CODEC enable real-time recording and

playback for high-quality images and video.

Note: The digital sensors that U10 module supports are OV2655 and OV3640 by default. Camera module with other sensors could also be supported upon request.

The following table shows the pin definition of camera interface.

Table 23: Pin definition of the camera interface

Pin Name	Pin NO.	I/O	Function
CAM_PWR_EN	16	O	External LDO control pin for power supply of sensor analog circuit and sensor array
VCAMA	26	P	Power supply for sensor IO circuit
VCAMD	28	P	Power supply for digital core
CS_D0	30	I	Camera interface pixel data bit 0
CS_D1	32	I	Camera interface pixel data bit 1
CS_D2	40	I	Camera interface pixel data bit 2
CS_D3	36	I	Camera interface pixel data bit 3
CS_D4	34	I	Camera interface pixel data bit 4
CS_D5	38	I	Camera interface pixel data bit 5
CS_D6	42	I	Camera interface pixel data bit 6
CS_D7	46	I	Camera interface pixel data bit 7
CS_D8	48	I	Camera interface pixel data bit 8
CS_D9	52	I	Camera interface pixel data bit 9
CS_HSYNC	56	I	Horizontal sync from camera
CS_VSYNC	54	I	Vertical sync from camera
CS_PCLK	44	I	Pixel clock from camera
CS_RST	60	O	Reset the camera
CS_MCLK	50	O	Master clock to the camera sensor
CS_PWDN	58	O	Power down the camera
CS_SDA	39	IO	I2C data Pin for Camera
CS_SCL	37	O	I2C clock Pin for Camera

The following figure shows the reference design of camera interface.

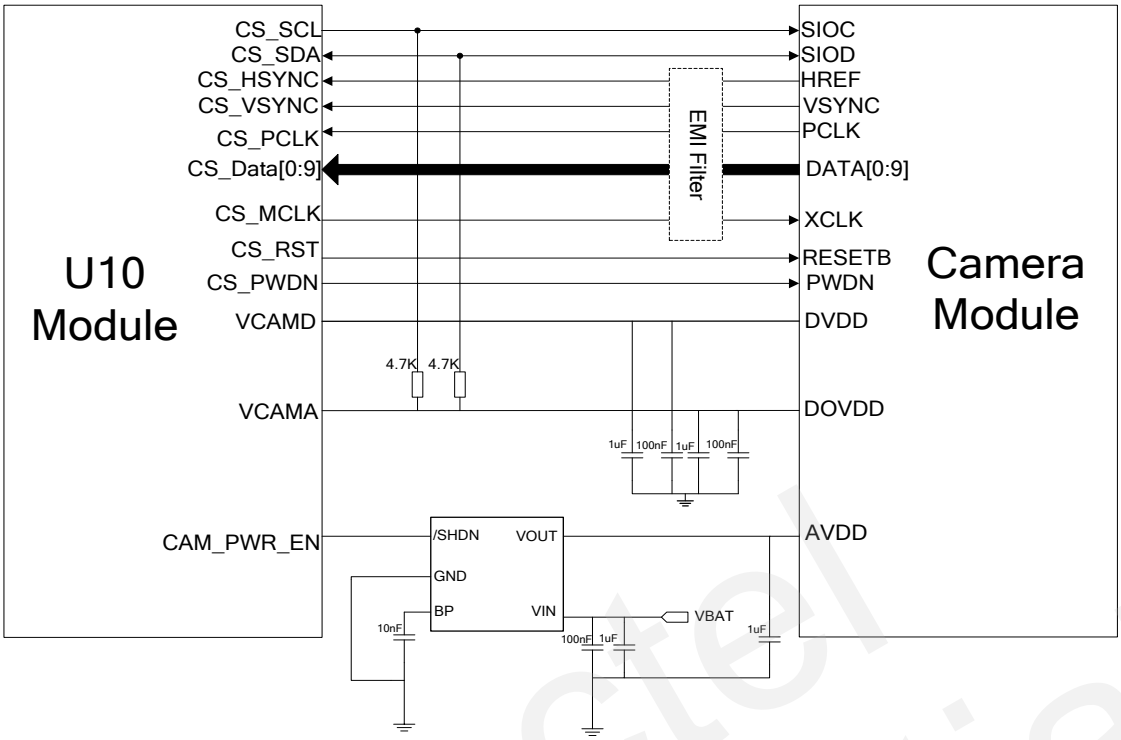


Figure 39: Reference design with digital CMOS sensor

Note: When customer use a YUV camera sensor, the camera module's data line data0~data7 should be connected to the module's CS_D2~CS_D9 and discard CS_D0~CS_D1.

- The data and clock lines of camera are sensitive to the capacitance. Generally the EMI components have a larger value of capacitance. If those components are put on to the parallel line then the signal will fade a lot. In order to improve the signal quality, the capacitance of the EMI filter should be smaller than 15pF.
- If use the external ISP (Image Signal Process), please check VCAMD current. The VCAMD Rated Current is 100mA.
- CAM_PWR_EN is used to control the SHDN pin of external LDO. The default value is low which means turn-off. The LDO output voltage is 2.8V and the rated current should be more than 300mA with high PSRR.

3.12.2. Analog sensor

U10 also supports analog sensor which needs a video decoder. It is recommended to use AK8856 from Japanese AKM Co., Ltd which can decode NTSC or PAL composite video signals into digital video data, and with the AK8856 you can use analog sensor as video source. The output signal must be compatible with CCIR656/CCIR601 in YUV442 format.

The following figure shows the reference design of analog sensor with AK8856. For more details, please contact us and give us your request.

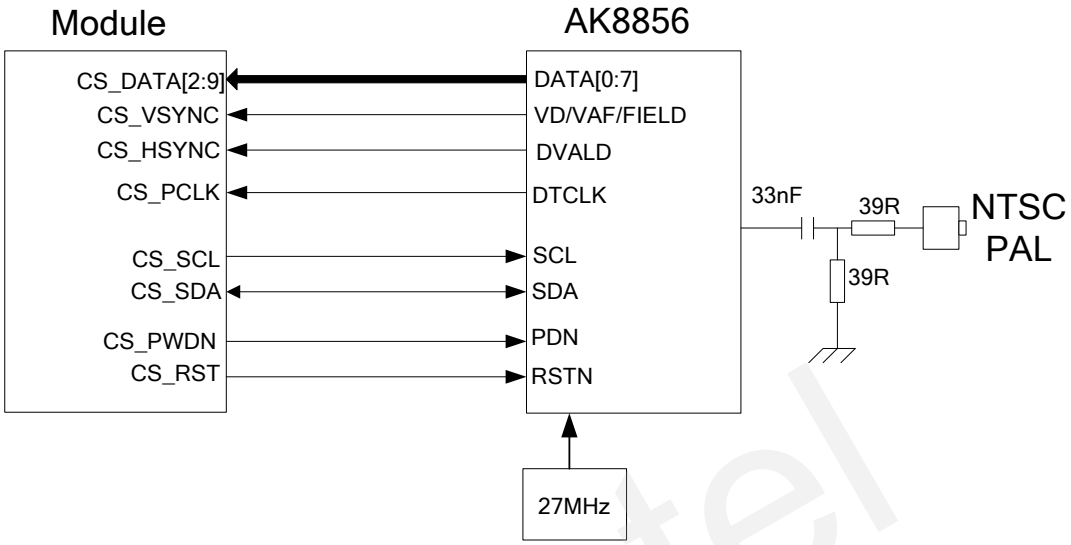


Figure 40: Reference design of using decoder IC for CVBS signal

3.13. ADC

The module provides two 12 bits analog-to-digital converter (ADC) to digitize the analog signal to 12-bit digital data such as battery voltage, temperature and so on. Using AT command "AT+QADC" can read the voltage value on ADC0 pin. Using AT command "AT+QEADC" can read the voltage value on ADC1 pin. For more details of these AT commands, please refer to ***document [1]*.**

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

Table 24: Pin definition of the ADC

Pin Name	Pin NO.	Function
ADC0	23	Analog to digital converter
ADC1	25	Analog to digital converter

Table 25: Characteristics of the ADC

Item	Min	Type	Max	Units
Voltage Range(ADC0)	0		2.5	V
Voltage Range(ADC1)	0		2.5	V
ADC Resolution		12		bits
ADC Accuracy		0.6		mV

3.14. Behaviors of the RI

Table 26: Behaviors of the RI

State	RI response
Standby	HIGH
Voice calling	Changed to LOW, then: 1. Changed to HIGH when call is established. 2. Use ATH to hang up the call, RI changes to HIGH. 3. Calling part hangs up, RI changes to HIGH first, and changes to LOW for 120ms indicating "NO CARRIER" as an URC, then changes to HIGH again. 4. Changed to HIGH when SMS is received.
Data calling	Changed to LOW, then： 1. Changed to HIGH when data connection is established. 2. Use ATH to hang up the data calling, RI changes to HIGH. 3. Calling part hangs up, RI changes to HIGH first, and changes to LOW for 120ms indicating "NO CARRIER" as an URC, then changes to HIGH again. 4. Changed to HIGH when SMS is received.
SMS	When a new SMS comes, the RI changes to LOW and holds low level for about 120 ms, then changes to HIGH.
URC	Certain URCs can trigger 120ms low level on RI. For more details, please refer to the ***document [1]***

If the module is used as a caller, the RI would maintain high except the URC or SMS is received. On the other hand, when it is used as a receiver, the timing of the RI is shown below.

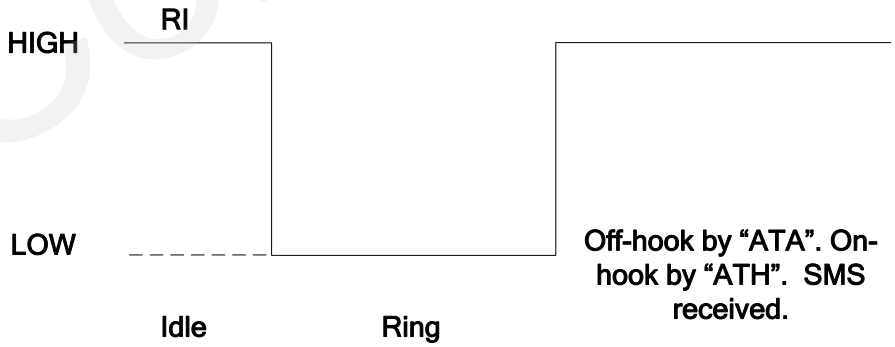


Figure 41: RI behaviours of voice calling as a receiver

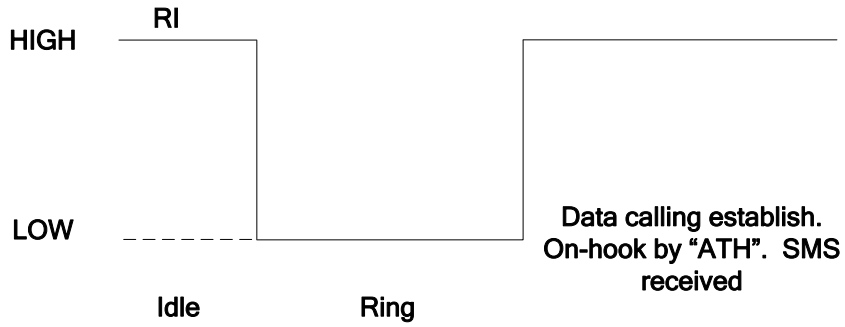


Figure 42: RI behaviour of data calling as a receiver

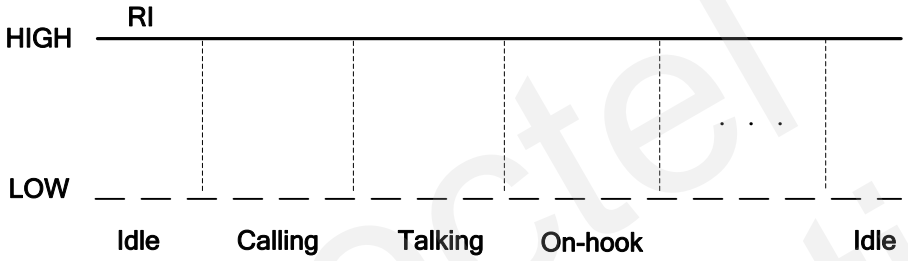


Figure 43: RI behaviours as a caller

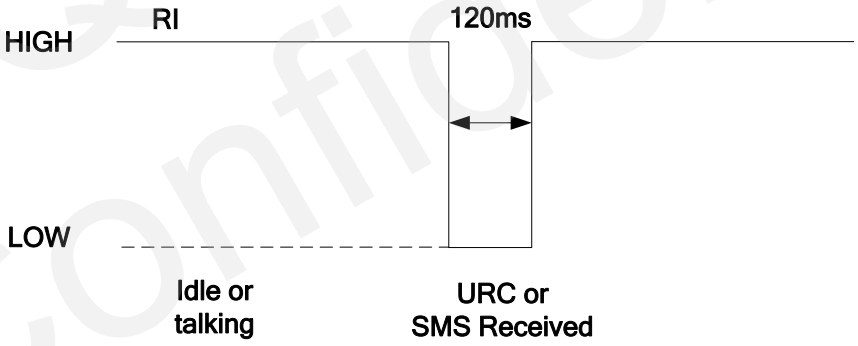


Figure 44: RI behaviours of URC or SMS received

3.15. Network status indication

The NETLIGHT signal can be used to drive a network status indicator LED. The module provides two NETLIGHT pins. Currently the NETLIGHT2 is not supported. The Pin definition of the NETLIGHT is listed in Table 27 and the working state of NETLIGHT1 is listed in Table 28.

Table 27: Pin definition of the NETLIGHT

Pin Name	Pin NO.	Function
NETLIGHT1	68	Pin 1 of the network status
NETLIGHT2	80	Pin 2 of the network status

Table 28: Working state of the NETLIGHT1

State	Network Status
Off	The module is not running.
35ms On/ 500ms Off	The module is not synchronized with network.
70ms On/ 1000ms Off	The module is synchronized with network.
23ms On/ 333ms Off	Data transfer is ongoing with GSM network.
11ms On/ 162ms Off	Data transfer is ongoing with 3G network.

A reference circuit is shown in Figure 45.

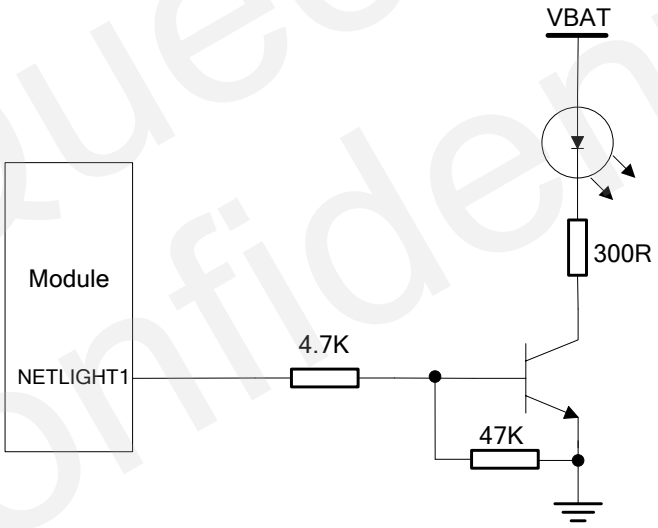


Figure 45: Reference design of the NETLIGHT1

3.16. Operating status indication

The STATUS pin is set as an output pin and can be used to judge whether module is power-on. In customer's design, this pin can be connected to a GPIO of DTE or be used to drive an LED in order to judge the module's operation status. A reference circuit is shown in Figure 46.

Table 29: Pin definition of the STATUS

Pin Name	Pin NO.	Function
STATUS	21	Indicate module's operation status

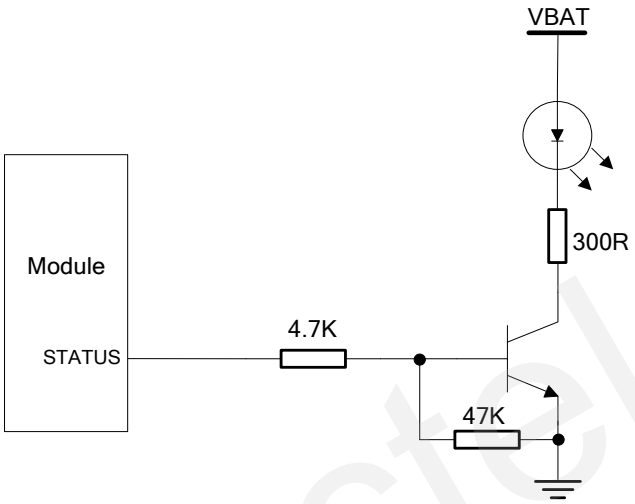


Figure 46: Reference design of the STATUS

4. Antenna interface

The RF interface has an impedance of 50 ohm. U10 module uses an RF connector for connecting the module to the antenna.

To minimize the loss on the RF cable, it needs to be very careful to choose RF cable. It is recommended that the insertion loss should meet the following requirements:

- GSM850/EGSM900 <1dB
- DCS1800/PCS1900 <1.5dB
- WCDMA 1900/2100 <1.5dB
- WCDMA 850 <1dB

4.1. Antenna installation

4.1.1. Antenna connector

The module uses HIROSE UF.L-R-SMT RF connector on the module side. So we recommend that customer can use U.FL-LP serial connector listed on Figure 49 to match the UF.L-R-SMT. For more details, please visit http://www.hirose.com/.

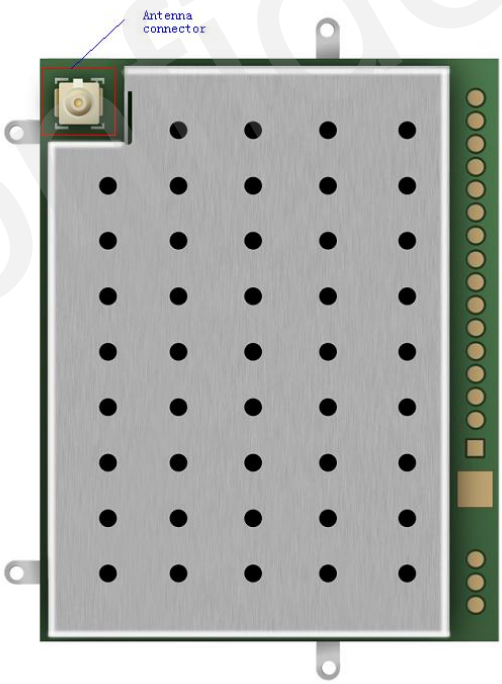


Figure 47: Antenna connector

4.1.2. Physical photo of the UF.L-R-SMT connector

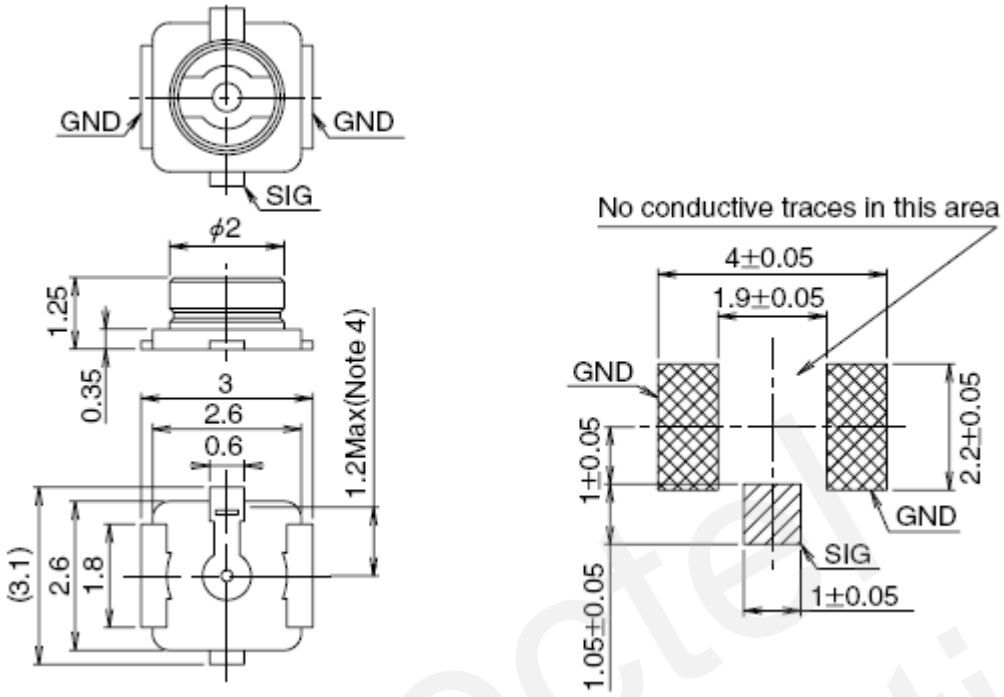


Figure 48: Dimensions of the UF.L-R-SMT connector（Unit：mm）

4.1.3. Matching connector on the application side

Five types of female connector can match UF.L-R-SMT. The mechanical dimensions of them are listed in the following figure:

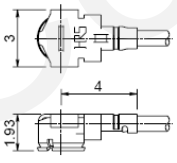
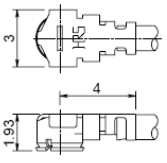
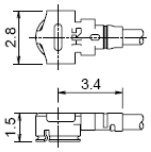
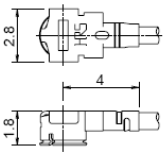
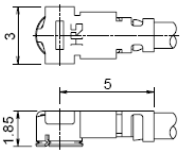
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Figure 49: Mechanical dimensions of UF.L-LP connectors

4.1.4. Space factor of mated connector

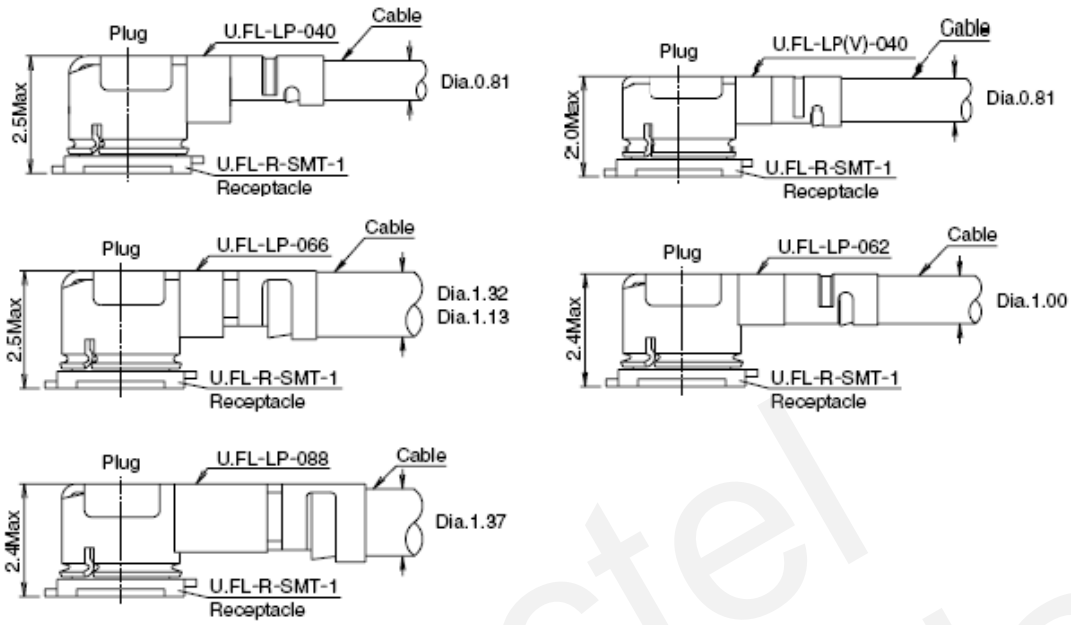


Figure 50: Space factor of mated connector（Unit: mm）

4.2. RF output power

Table 30: The module conducted 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(8PSK)	27dBm ±3dB	5dBm±5dB
GSM900(8PSK)	27dBm ±3dB	5dBm±5dB
DCS1800(8PSK)	26dBm ±3dB	0dBm±5dB
PCS1900(8PSK)	26dBm ±3dB	0dBm±5dB
WCDMA 2100	24dBm+1/-3db	<-50dBm
WCDMA 1900	24dBm+1/-3db	<-50dBm
WCDMA 850	24dBm+1/-3db	<-50dBm

Note: In GPRS 4 slots TX mode, the max output power is reduced by 2.5dB. This design conforms to the GSM specification as described in section 13.16 of 3GPP TS 51.010-1.

4.3. RF receiving sensitivity

Table 31: The module conducted RF receiving sensitivity

Frequency	Receive sensitivity
GSM850	< -108.5dBm
EGSM900	< -108.5dBm
DCS1800	< -108.7dBm
PCS1900	< -108.7dBm
WCDMA 2100	< -109.5dBm
WCDMA 1900	< -109.5dBm
WCDMA 850	< -106.5dBm

4.4. Module operating frequencies

Table 32: The module operating frequencies

BAND	Receive	Transmit
GSM850	869 ~ 894MHz	824 ~ 849MHz
EGSM900	925 ~ 960MHz	880 ~ 915MHz
DCS1800	1805 ~ 1880MHz	1710 ~ 1785MHz
PCS1900	1930 ~ 1990MHz	1850 ~ 1910MHz
WCDMA 2100	2110 ~2170MHz	1920 ~ 1980MHz
WCDMA 1900	1930 ~ 1990MHz	1850 ~ 1910MHz
WCDMA 850	869 ~ 894MHz	824 ~ 849MHz

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 module are listed in the following table:

Table 33: Absolute maximum ratings

Parameter	Min	Max	Unit
VBAT	-0.3	+4.73	V
Peak current of power supply	0	2	A
RMS current of power supply (during one TDMA- frame)	0	0.7	A
RMS current of power supply (during WCDMA Max power transmission)	0	0.6	A
Voltage at digital pins	-0.3	3.3	V
Voltage at analog pins	-0.3	3.0	V

5.2. Operating temperature

The operating temperature is listed in the following table:

Table 34: Operating temperature

Parameter	Min	Type	Max	Unit
Normal Temperature	-35	25	80	℃
Restricted Operation[1)]	-40 ~ -35		80 ~ 85	℃
Storage Temperature	-45		+90	℃

1) When the module works beyond the temperature range, the deviations from the RF specification may occur. For example, the frequency error or the phase error will be increased.

5.3. Power supply ratings

Table 35: The module power supply ratings

Parameter	Description	Conditions	Min	Type	Max	Unit
VBAT	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple, and spikes.	3.4	4.0	4.6	V
	Voltage drop during transmitting burst	Maximum power control level on GSM850 and GSM900.			400	mV
I_{VBAT}	Average supply current	POWER DOWN mode SLEEP mode		TBD TBD		
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and GSM900.		1.6	2	A

5.4. Current consumption

The values of current consumption are shown in Table 36.

Table 36: The module current consumption

Condition	Current Consumption
GSM Sleep	TBD
Voice Call	
GSM850	@power level #5 <300mA,Typical 250mA
GSM900	@power level #5 <300mA,Typical 260mA
DCS1800	@power level #0 <250mA,Typical 200mA
PCS1900	@power level #0 <250mA,Typical 190mA
GPRS Data	
DATA mode, GPRS (1 Rx,1 Tx) CLASS 12	
GSM850	@power level #5 <350mA,Typical 245mA
EGSM 900	@power level #5 <350mA,Typical 259mA
DCS 1800	@power level #0 <300mA,Typical 215mA
PCS 1900	@power level #0 <300mA,Typical 195mA
DATA mode, GPRS (3 Rx, 2 Tx) CLASS 12	

GSM850	@power level #5 <550mA,Typical 385mA
EGSM 900	@power level #5 <550mA,Typical 390mA
DCS 1800	@power level #0 <450mA,Typical 310mA
PCS 1900	@power level #0 <450mA,Typical 270mA
DATA mode, GPRS (2 Rx, 3 Tx) CLASS 12	
GSM850	@power level #5 <600mA,Typical 450mA
EGSM 900	@power level #5 <600mA,Typical 463mA
DCS 1800	@power level #0 <490mA,Typical 352mA
PCS 1900	@power level #0 <480mA,Typical 310mA
DATA mode, GPRS (1 Rx, 4 Tx) CLASS 12	
GSM850	@power level #5 <660mA,Typical 531mA
EGSM 900	@power level #5 <660mA,Typical 550mA
DCS 1800	@power level #0 <530mA,Typical 410mA
PCS 1900	@power level #0 <530mA,Typical 360mA
EDGE Data	
DATA mode, EDGE (3 Rx, 2 Tx) CLASS 12	
GSM850	@power level #8 <330mA,Typical 260mA
EGSM 900	@power level #8 <330mA,Typical 280mA
DCS 1800	@power level #2 <300mA,Typical 275mA
PCS 1900	@power level #2 <300mA,Typical 264mA
DATA mode, EDGE (1 Rx, 4 Tx) CLASS 12	
GSM850	@power level #8 <500mA,Typical 345mA
EGSM 900	@power level #8 <500mA,Typical 370mA
DCS 1800	@power level #2 <450mA,Typical 395mA
PCS 1900	@power level #2 <450mA,Typical 390mA
UMTS Sleep	
WCDMA Sleep	TBD
UMTS Voice call	
WCDMA 2100	@power 24dBm,Typical 465mA @power 10dBm,Typical 215mA @power -50dBm,Typical 170mA
WCDMA 1900	@power 24dBm,Typical 470mA @power 10dBm,Typical 220mA @power -50dBm,Typical 175mA
WCDMA 850	@power 24dBm,Typical 465mA @power 0dBm,Typical 210mA @power -50dBm,Typical 170mA
HSPA Data	
WCDMA 2100	@power 24dBm,Typical 570mA
WCDMA 1900	@power 24dBm,Typical 510mA
WCDMA 850	@power 24dBm,Typical 525mA

5.5. Electro-static discharge

Although the module is generally protected against Electrostatic Discharge (ESD), ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operating any applications using the module.

The measured ESD values of module are shown as the following table:

Table 37: The ESD endurance (Temperature:25℃,Humidity:45 %)

Tested point	Contact discharge	Air discharge
VBAT,GND	±5KV	±10KV
RF_ANT	±5KV	±10KV
PWRKEY	±4KV	±8KV
SIM1_VDD, SIM1_DATA SIM1_CLK, SIM1_RST	±4KV	±8KV
UART Port	±4KV	±8KV
USB_DP, USB_DM	±4KV	±8KV
Others	±0.5KV	±1KV

6. Mechanical dimensions

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical dimensions of module

The following figures show the U10's top view, side view and bottom view. These figures illustrate mechanical dimensions of the module.

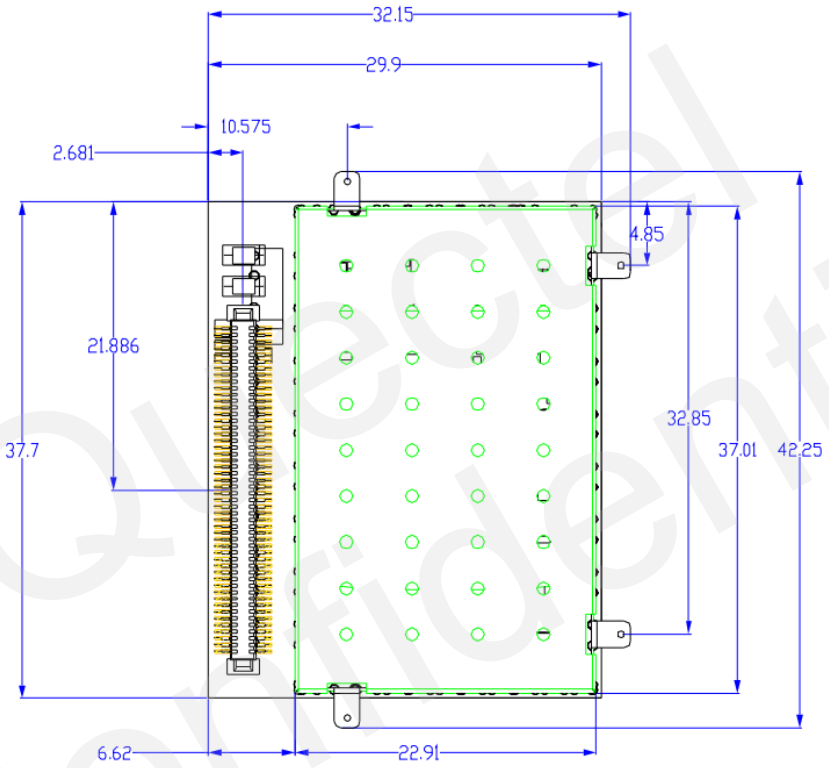


Figure 51 U10 TOP dimension (Unit: mm)

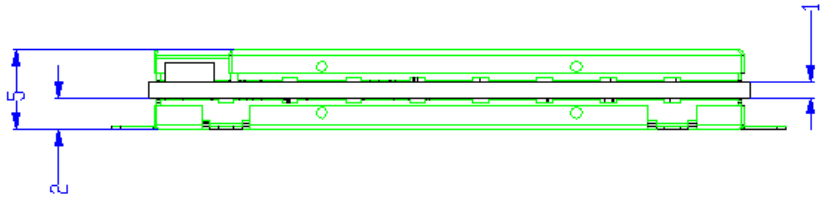


Figure 52: U10 SIDE dimension (Unit: mm)

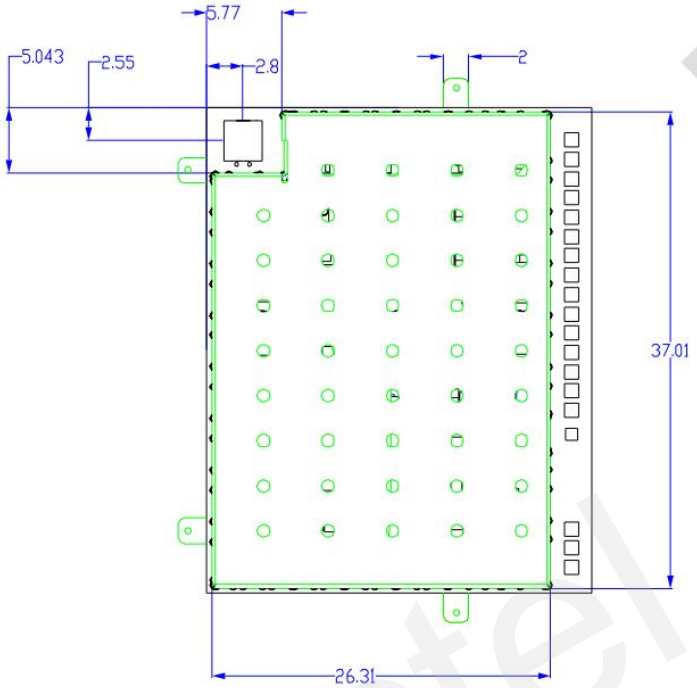


Figure 53: U10 BOT dimension (Unit: mm)

6.2. Board to board connector

The module uses the Panasonic 100 pin board-to-board connector AXK6F00347YG and four mounting pads to fix onto the customer platform. The connector's sketch map is given in Figure 54. The value of parameter A, B and C is as follow:
A=28mm, B=24.5mm, C=1.25mm

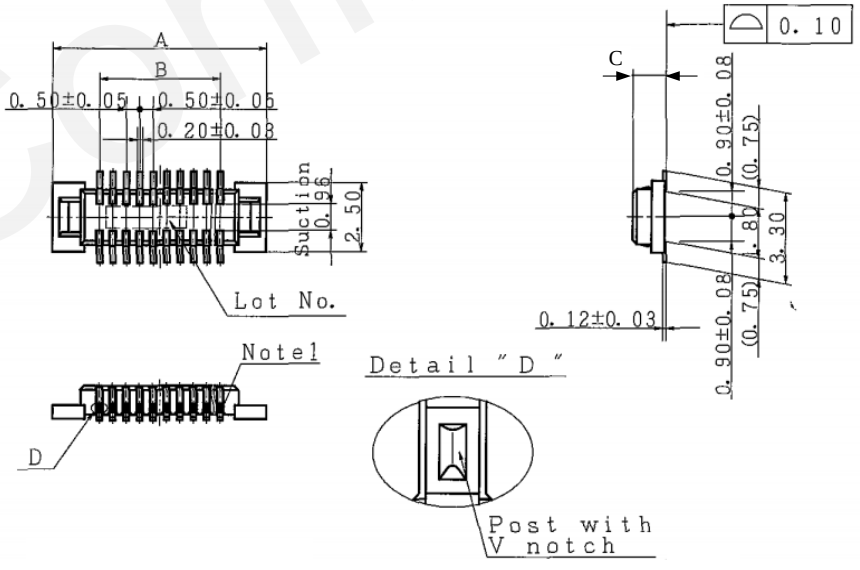


Figure 54: Sketch map of board to board connector (Unit: mm)

It is recommended to use the AXK5F00547YG, which is produced by Panasonic, as the socket on the customer's host board. Its sketch map is given in Figure 55. The value of parameter A, B and C is as follow:

A=28mm, B=24.5mm, C=1.85mm

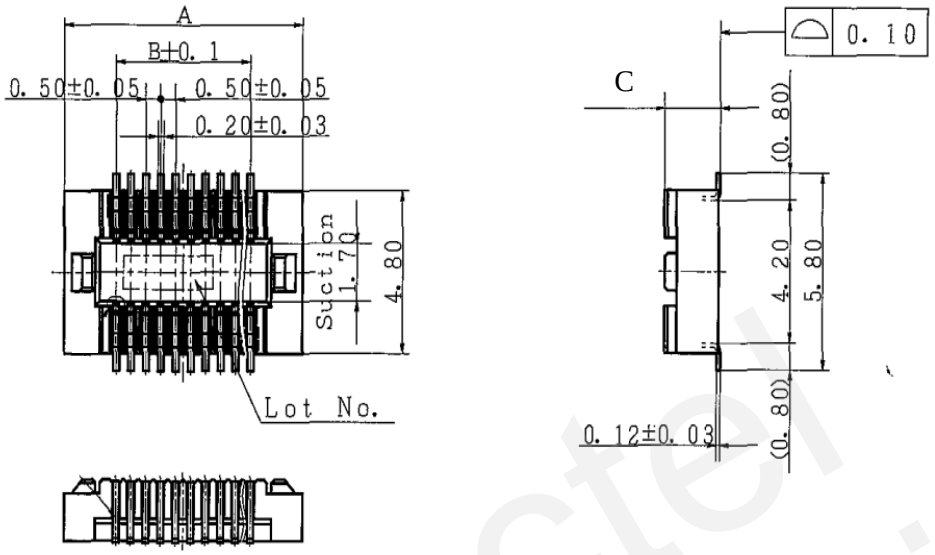


Figure 55: Sketch map of 100 pin board to board socket (Unit: mm)

For more details, please visit http://pewa.panasonic.com/

6.3. Mount U10 onto the application platform

The following figure shows the pin sequence of the module. We also use four mounting pads for fixing the module to make sure the structure is secure.

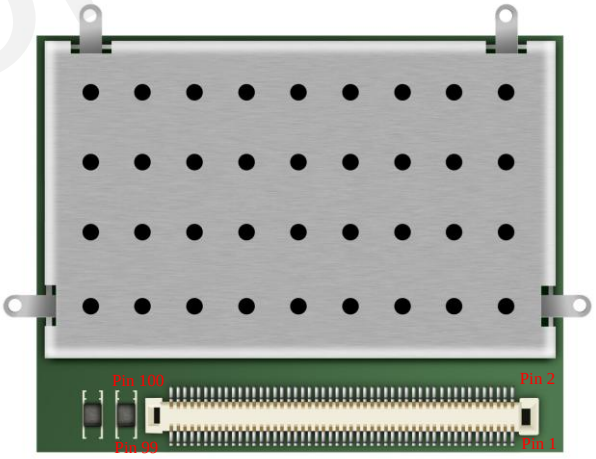


Figure 56: Pin sequence of the module

Please pay attention to that the pin sequence of U10 is mirror image of pin sequence of 100-pin socket connector on host.

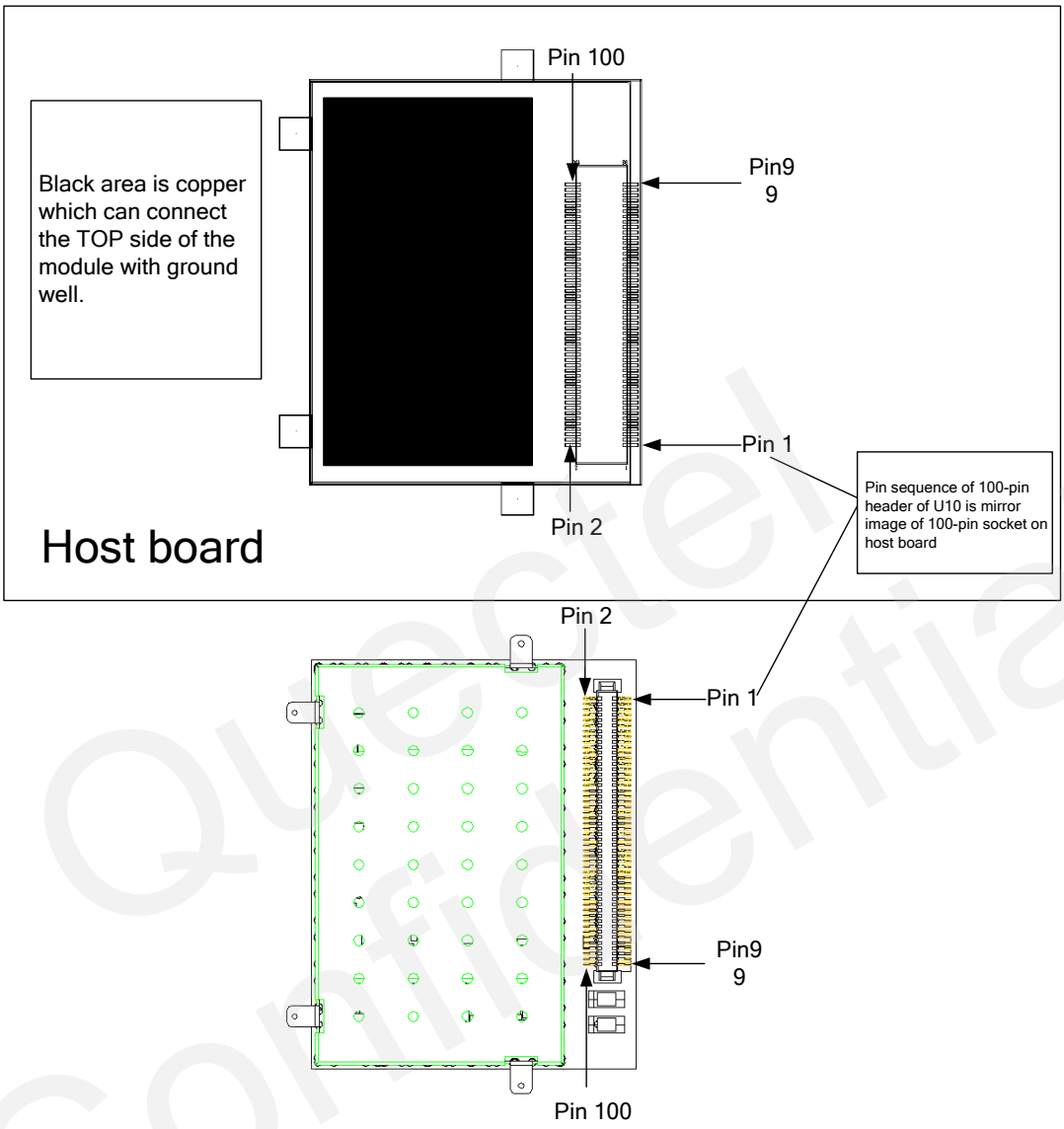


Figure 57: Mirror image of pin sequence

6.4. Footprint of recommendation

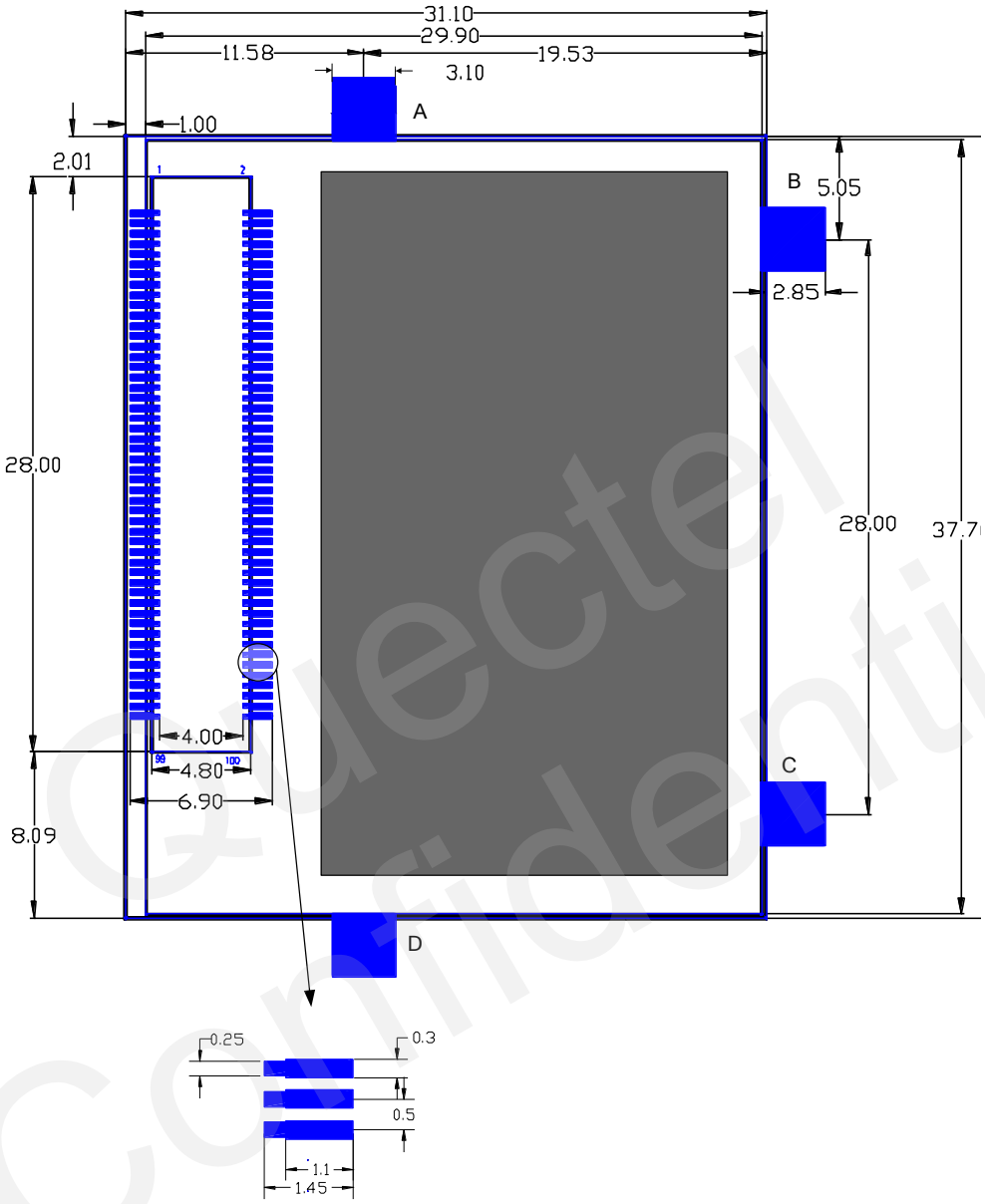


Figure 58: Recommended footprint (unit: mm)

Note: ***1) The four mounting pads A, B, C and D do not need paste mask.***
2) The gray area is the copper that designed for well grounding.

6.5. Top view of the module

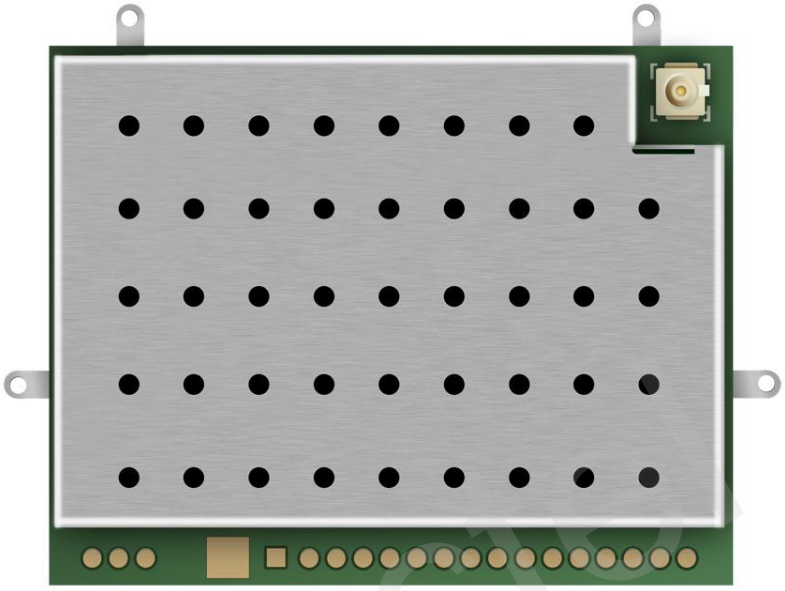


Figure 59: TOP view of U10

6.6. Bottom view of the module

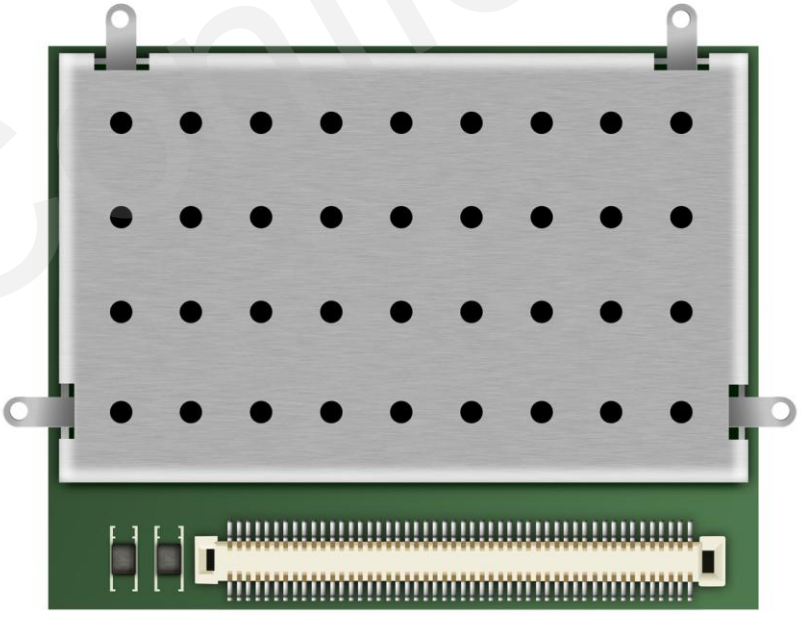


Figure 60: BOT view of U10

7. Storage and Manufacturing

7.1. Storage

U10 is stored in the vacuum-sealed bag. The restriction of storage condition is shown as below. Shelf life in sealed bag is 12 months at <40℃/ 90%RH.

7.2. Packaging

U10 modules are distributed in trays of 20 pieces each. The trays are stored inside a vacuum-sealed bag which is ESD protected. It should not be opened until the devices are ready to be assembled onto the application.

Figure 61: Module tray

Appendix A: GPRS coding schemes

Four coding schemes are used in GPRS protocol. The differences between them are shown in Table 38.

Table 38: 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

Radio block structure of CS-1, CS-2 and CS-3 is shown as Figure 62:

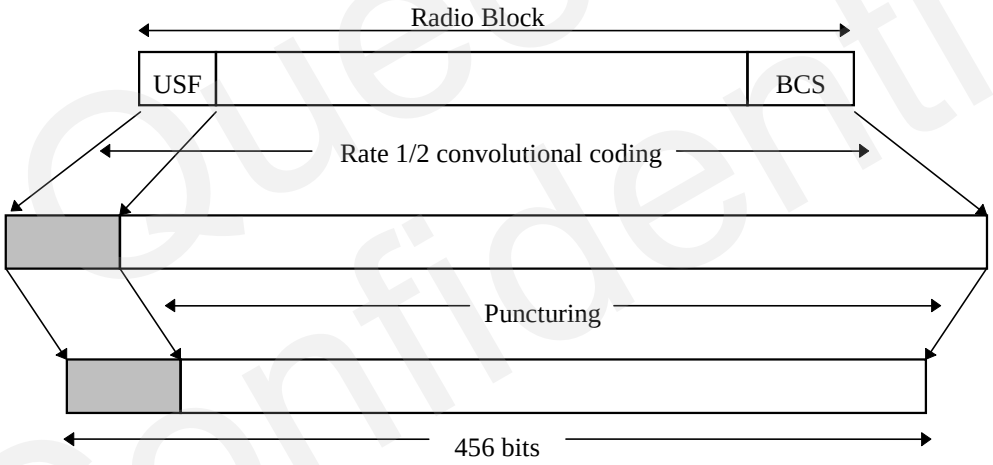


Figure 62: Radio block structure of CS-1, CS-2 and CS-3

Radio block structure of CS-4 is shown as Figure 63:

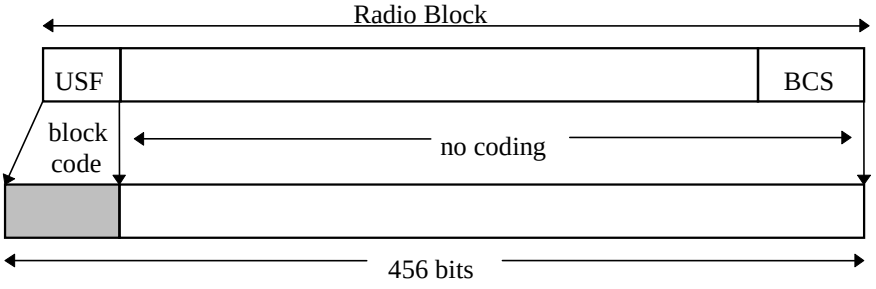


Figure 63: Radio block structure of CS-4

Appendix B: GPRS multi-slot classes

Twenty-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 Table 39.

Table 39: 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

Appendix C: EDGE modulation and coding scheme

Table 40: EDGE modulation and coding scheme

Coding scheme	Modulation	Coding family	1 Timeslot	2 Timeslot	4 Timeslot
MCS-1	GMSK	C	8.80 kbps	17.60 kbps	35.20 kbps
MCS-2	GMSK	B	11.2 kbps	22.4 kbps	44.8 kbps
MCS-3	GMSK	A	14.8 kbps	29.6 kbps	59.2 kbps
MCS-4	GMSK	C	17.6 kbps	35.2 kbps	70.4 kbps
MCS-5	8-PSK	B	22.4 kbps	44.8 kbps	89.6 kbps
MCS-6	8-PSK	A	29.6 kbps	59.2 kbps	118.4 kbps
MCS-7	8-PSK	B	44.8 kbps	89.6 kbps	179.2 kbps
MCS-8	8-PSK	A	54.4 kbps	108.8 kbps	217.6 kbps
MCS-9	8-PSK	A	59.2 kbps	118.4 kbps	236.8 kbps

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