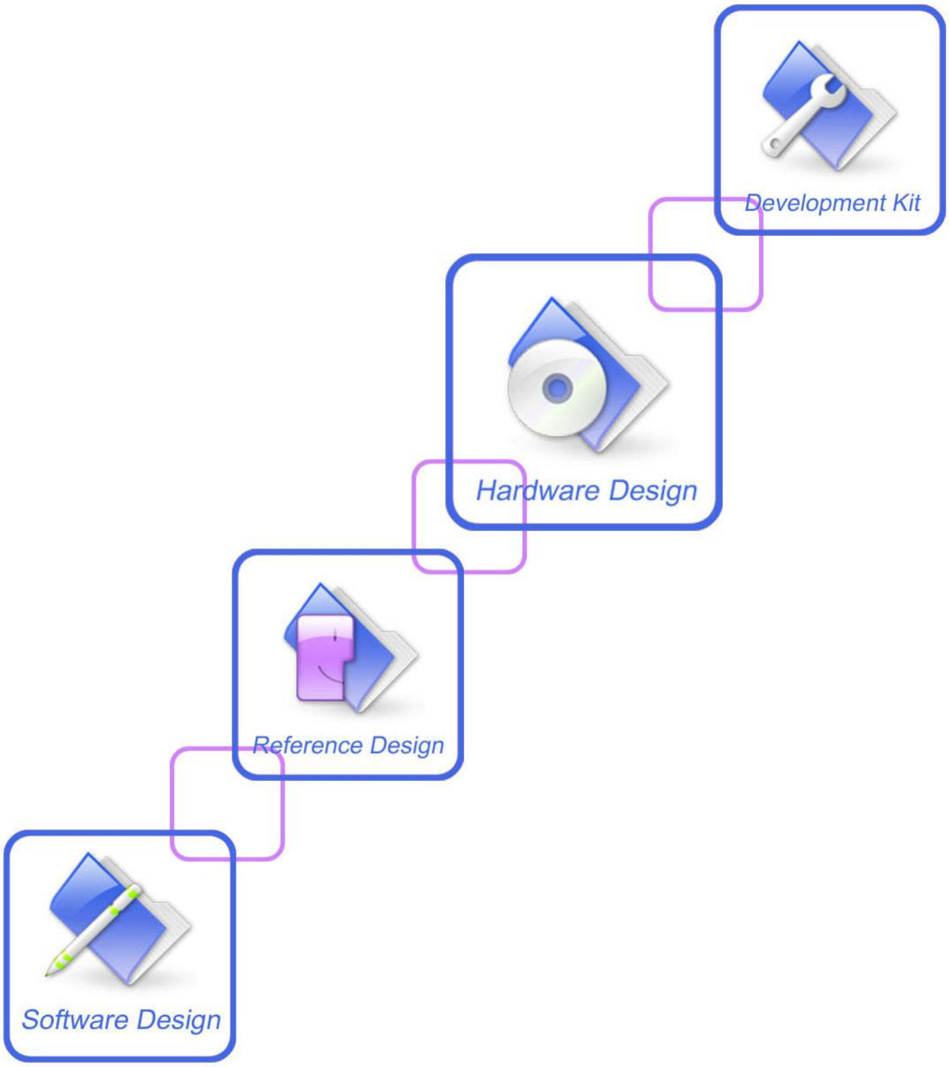
Heracles 224G _Hardware Design_V1.00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Hardware Design
Reference Design
Software Design

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Contents

Contents 3

Table Index 5

Figure Index 7

Revision History 8

1 Introduction 9
- 1.1 Product Outline 10
- 1.2 Hardware Interface Overview 11
- 1.3 Hardware Block Diagram 12
- 1.4 Functional Overview 13

2 Package Information 15
- 2.1 Pin Assignment Overview 15
- 2.2 Pin Description 16
- 2.3 Mechanical Information 19
- 2.4 Footprint Recommendation 20

3 Interface Application 21
- 3.1 Power Supply 21
  - 3.1.1 Power Supply Design Guide 21
  - 3.1.2 Recommended Power Supply Circuit 22
  - 3.1.3 Voltage Monitor 23
- 3.2 Power on/Power off/Reset Function 24
  - 3.2.1 Power on 24
  - 3.2.2 Power off 25
  - 3.2.3 Reset Function 27
- 3.3 UART Interface 28
  - 3.3.1 UART Design Guide 28
  - 3.3.2 RI and DTR Behavior 29
- 3.4 USB Interface 30
- 3.5 SIM Interface 31
  - 3.5.1 SIM Application Guide 32
- 3.6 PCM Interface 33
  - 3.6.1 PCM timing 33
  - 3.6.2 PCM Application Guide 35
- 3.7 I2C Interface 35
- 3.8 Network status 36
- 3.9 Other interface 37
  - 3.9.1 ADC 37
  - 3.9.2 LDO 37

4 RF Specifications 38
- 4.1 GSM/LTE RF Specifications 38
- 4.2 GSM/LTE Antenna Design Guide 42

4.3 GNSS 43
4.3.1 GNSS Technical specification 43
4.3.2 GNSS Application Guide 43
4.4 RF traces note 45

4.4.1 RF traces layout 45

4.4.2 LTE ANT and other system ANT decoupling 46

5 Electrical Specifications 47
5.1 Absolute maximum ratings 47
5.2 Operating conditions 48
5.3 Operating Mode 49
5.3.1 Operating Mode Definition 49
5.3.2 Sleep mode 50
5.3.3 Minimum functionality mode and Flight mode 50
5.3.4 Power Saving Mode (PSM) 51
5.3.5 Extended Mode DRX (e-DRX) 51
5.4 Current Consumption 53
5.5 ESD Notes 56

6 SMT Production Guide 57
6.1 Top and Bottom View of HERACLES 224G 57
6.2 Label Information 58
6.3 Typical SMT Reflow Profile 59
6.4 Moisture Sensitivity Level (MSL) 60
6.5 Baking 61
6.6 Stencil Foil Design Recommendation 62

7 Packaging 63
7.1 Tray packaging 63

Appendix 66
A. Design check list 66
B. Coding Schemes and Maximum Net Data Rates over Air Interface 68
C. Related Documents 70
D. Terms and Abbreviations 72
E. Safety Caution 74

Table Index

Table 1: HERACLES 224G frequency bands and air interface 10
Table 2: General features 13
Table 3: IO parameters definition 16
Table 4: Pin description 16
Table 5: VBAT pins electronic characteristic 21
Table 6: Recommended TVS diode list 22
Table 7: Power on timing and electronic characteristic 24
Table 8: Power off timing and electronic characteristic 26
Table 9: RESET pin electronic characteristic 27
Table 10: UART electronic characteristic 28
Table 11: SIM electronic characteristic in 1.8V mode (SIM_VDD=1.8V) 31
Table 12: SIM electronic characteristic 3.0V mode (SIM_VDD=2.95V) 31
Table 13: PCM format 33
Table 14: PCM timing parameters 34
Table 15: NETLIGHT pin status 36
Table 16: ADC electronic characteristics 37
Table 17: Electronic characteristic 37
Table 18: Conducted transmission power 38
Table 19: Maximum Power Reduction (MPR) for UE category NB1 Power Class 3 38
Table 20: Operating frequencies 39
Table 21: E-UTRA operating bands 39
Table 22: Conducted receive sensitivity 39
Table 23: CAT-M1 Reference sensitivity (QPSK) 40
Table 24 : FDD and TDD UE category M1 Uplink configuration for reference sensitivity 40
Table 25: Trace loss 42
Table 26: Recommended TVS 42
Table 27: Absolute maximum ratings 47
Table 28: Recommended operating ratings 48
Table 29: 1.8V Digital I/O characteristics* 48
Table 30: Operating temperature 48
Table 31: Operating mode Definition 49
Table 32: Current consumption on VBAT Pins (VBAT=3.8V) 53
Table 33: The ESD performance measurement table (Temperature: 25℃, Humidity: 45%.) 56
Table 34: The description of label information 58
Table 35: Moisture Sensitivity Level and Floor Life 60
Table 36: Baking conditions 61
Table 37: Tray size 64
Table 38: Small Carton size 64
Table 39: Big Carton size 65
Table 40: Schematic Check List 66
Table 41: PCB Layout Check List 66
Table 42: Coding Schemes and Maximum Net Data Rates over Air Interface 68
Table 43: Related Documents 70

Table 44: Terms and Abbreviations......72
Table 45: Safety Caution......74

Figure Index

Figure 1: HERACLES 224G block diagram 12
Figure 2: Pin assignment overview 15
Figure 3: Dimensions (Unit: mm) 19
Figure 4: Footprint recommendation (Unit: mm) 20
Figure 5: Power supply application circuit 22
Figure 6: power supply reference circuit 22
Figure 7: Reference power on/off circuit 24
Figure 8: Power on timing sequence 24
Figure 9: Power off timing sequence 26
Figure 10: Reference reset circuit 27
Figure 11: UART full modem 28
Figure 12: UART null modem 28
Figure 13: Reference circuit of level shift 29
Figure 14: RI behaviour（SMS and URC report） 29
Figure 15: USB reference circuit 30
Figure 16: SIM interface reference circuit 32
Figure 17: PCM_SYNC timing 33
Figure 18: External codec to module timing 33
Figure 19: Module to external codec timing 34
Figure 20: Audio codec reference circuit 35
Figure 21: I2C reference circuit 35
Figure 22: NETLIGHT reference circuit 36
Figure 23：Power on sequence of the VDD_EXT 37
Figure 24: Antenna matching circuit (MAIN_ANT) 42
Figure 25: Passive antenna circuit 43
Figure 26: RF trace should be far away from other high speed signal lines 45
Figure 27: The distance between GND to the inner conductor of SMA 46
Figure 28: e-DRX diagrammatic sketch 51
Figure 29: Top and bottom view of HERACLES 224G 57
Figure 30: Label information 58
Figure 31: The ramp-soak-spike reflow profile of HERACLES 224G 59
Figure 32: stencil recommendation (Unit: mm) 62
Figure 33: packaging diagram 63
Figure 34: Tray drawing 63
Figure 35: Small carton drawing 64
Figure 36: Big carton drawing 64

Revision History

Data	Version	Description of change	Author
2018-10-3	1.00	Original	Tu Hongjun Gao Fan

1 Introduction

This document describes the electronic specifications, RF specifications, interfaces, mechanical characteristics and testing results of the SIMCom HERACLES 224G module. With the help of this document and other HERACLES 224G software application notes/user guides, users can understand and use HERACLES 224G module to design and develop applications quickly.

1.1 Product Outline

The HERACLES 224G series modules support LTE CAT-M1、 LTE CAT-NB1、GPRS and EDGE.
The physical dimension of HERACLES 224G is 24 × 27 × 2.6mm mm. And the Pin Description is compatible with Heracles.

Table 1: HERACLES 224G frequency bands and air interface

Standard	Frequency	Variants
GPRS	GSM850MHz	✓
	EGSM900MHz	✓
	DCS1800MHz	✓
	PCS1900MHz	✓
LTE-FDD HD-FDD	LTE-FDD B1	✓
	LTE-FDD B2	✓
	LTE-FDD B3	✓
	LTE-FDD B4	✓
	LTE-FDD B5	✓
	LTE-FDD B8	✓
	LTE-FDD B12	✓
	LTE-FDD B13	✓
	LTE-FDD B17	✓
	LTE-FDD B18	✓
	LTE-FDD B19	✓
	LTE-FDD B20	✓
	LTE-FDD B26	✓
	LTE-FDD B28	✓
	LTE-FDD B39	✓
Category	LTE-M1	✓
Category	LTE-NB1	✓
GNSS	GPS	✓
	GLONASS	✓
	BeiDou	✓
	Galileo	✓

Note: Galileo is default closed in software. But users can open it via AT command "AT+CGNSMOD". For more information about these AT commands, please refer to Document [1]

1.2 Hardware Interface Overview

The interfaces are described in detail in the next chapters include:

- Power Supply
- USB Interface
- UART Interface
- SIM Interface
- ADC
- PWM
- LDO Power Output
- PCM Interface
- I2C Interface
- GPIOs
- PWRKEY
- RESET
- Antenna Interface

1.3 Hardware Block Diagram

The block diagram of the HERACLES 224G module is shown in the figure below.

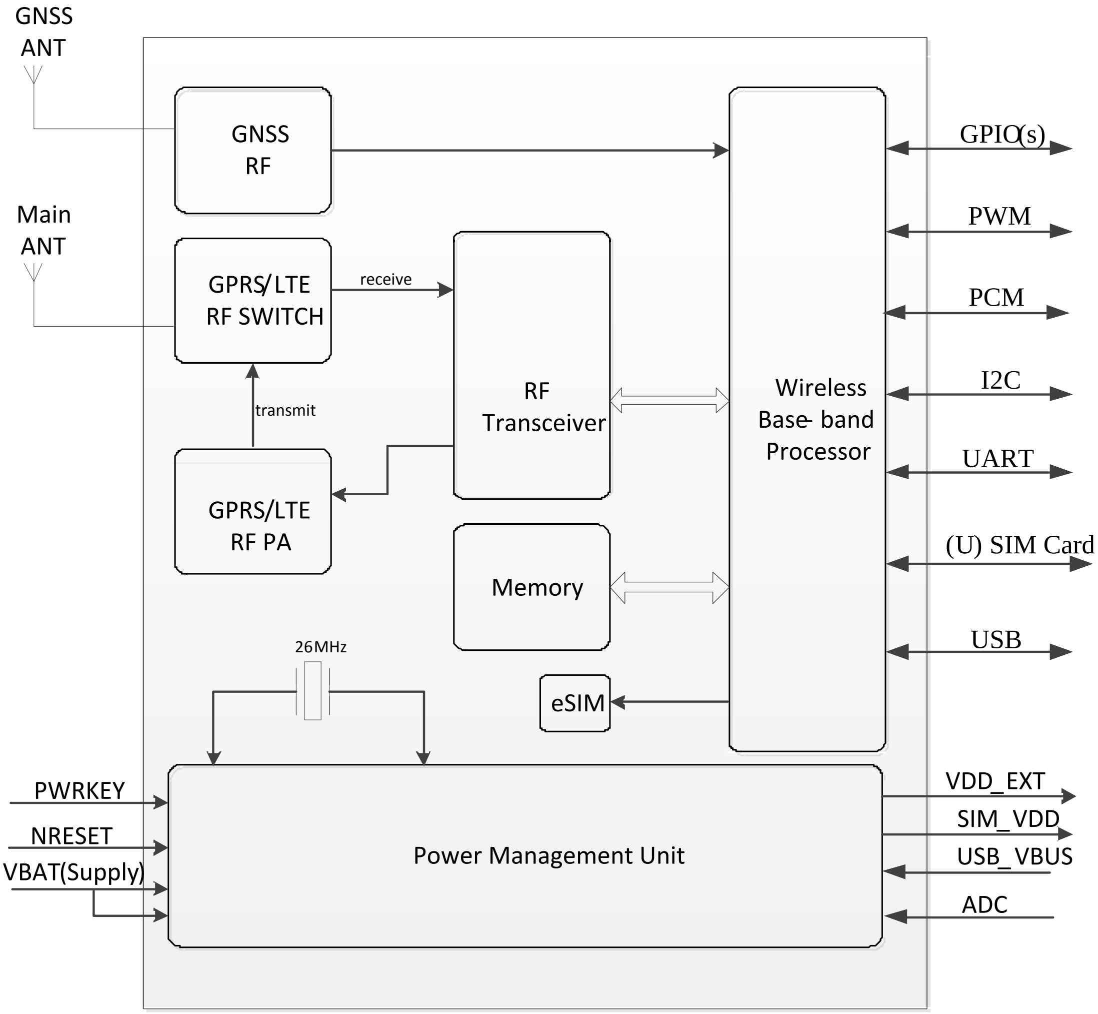

GNSS ANT
Main ANT
GNSS RF
GPRS/LTE RF SWITCH
receive
transmit
GPRS/LTE RF PA
RF Transceiver
Memory
Wireless Base- band Processor
26MHz
eSIM
GPIO(s)
PWM
PCM
I2C
UART
(U) SIM Card
USB
PWRKEY
NRESET
VBAT(Supply)
Power Management Unit
VDD_EXT
SIM_VDD
USB_VBUS
ADC

Figure 1: HERACLES 224G block diagram

1.4 Functional Overview

Table 2: General features

Feature	Implementation
Power supply	Power supply voltage 3.0～4.3V.
Power saving	Current in sleep mode: 1.2mA (@DRX=2.56s). Current in PSM mode: 9uA.
Radio frequency bands	Please refer to the table 1
Transmitting power	GPRS power class: --GSM850/EGSM900: 4 (2W). --DCS1800/PCS1900: 1 (1W). EDGE power class: -- GSM850/EGSM900: E2 (0.5W). -- DCS1800/PCS1900: E1 (0.4W). LTE power class: 3 (0.25W).
Data Transmission Throughput	GPRS multi-slot class 12. EDGE multi-slot class 12. LTE CAT M1: 300Kbps (DL). LTE CAT M1: 375Kbps (UL). LTE CAT NB1: 34Kbps (DL). LTE CAT NB1: 66Kbps (UL).
Antenna	GPRS/EDGE/LTE main antenna. GNSS antenna.
GNSS	GNSS engine (GPS, GLONASS, BD and Galileo). Protocol: NMEA.
SMS	MT, MO, CB, Text and PDU mode. SMS storage: SIM card or ME (default).
SIM interface	Support identity card: 1.8V/ 3V.
SIM application toolkit	Support SAT class 3, GSM 11.14 Release 98. Support USAT.
Audio feature	Support PCM interface. Only support PCM master mode and short frame sync, 16-bit linear data formats.
UART interface	A full modem serial port by default. Baud rate: 300bps to 3686400bps. Default rate is 0bps (auto baud rate). Support auto baud rate, but only limited to 9600, 19200, 38400, 57600 and 115200 bps. Can be used as the AT commands or data stream channel. Support RTS/CTS hardware handshake.
USB	USB 2.0 high speed interface.

Firmware upgrade	Firmware upgrade over USB interface
Physical characteristics	Size:24 × 27× 2.6mm Weight: 3g
Temperature range	Normal operation temperature: -30 ℃ to + 80 ℃ Extended operation temperature: -40 ℃ to + 85 ℃* Storage temperature -45 ℃ to + 90 ℃

Note: Module is able to make and receive voice calls, data calls, SMS and make GPRS/EDGE/LTE traffic in -40℃ ~ +85℃. The performance will be reduced slightly from the 3GPP specifications if the temperature is outside the normal operating temperature range and still within the extreme operating temperature range.

2 Package Information

2.1 Pin Assignment Overview

All functions of the HERACLES 224G will be provided through 68 pads that will be connected to the customers' platform. The following Figure is the pin assignment of the HERACLES 224G.

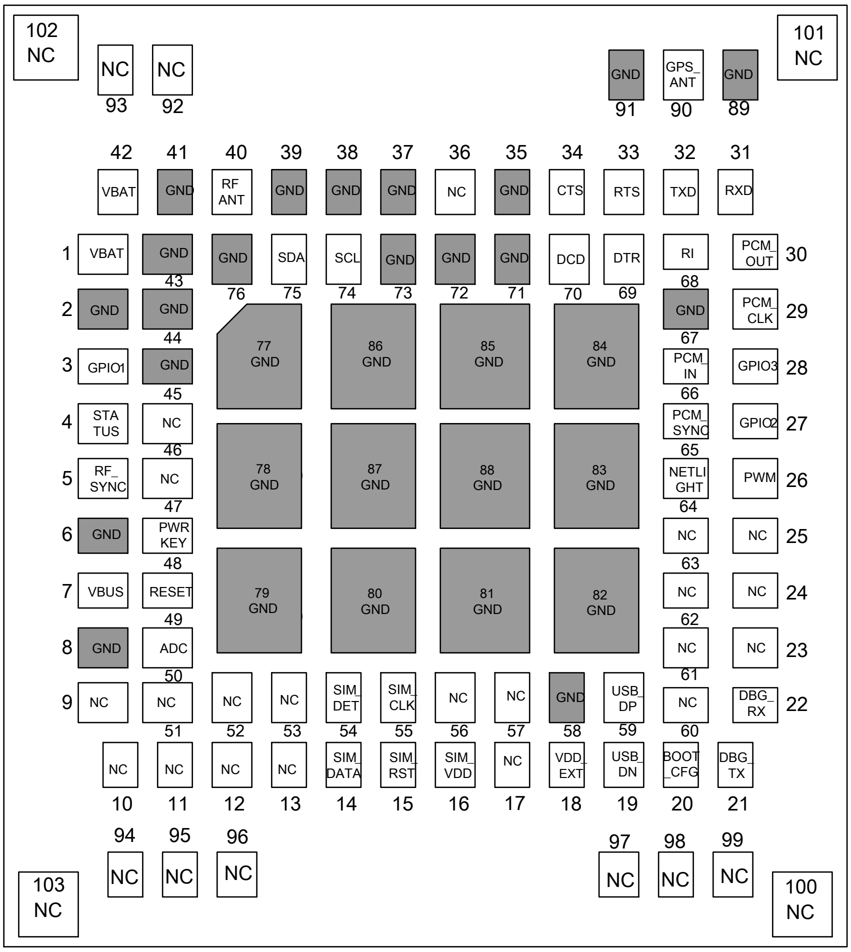

102 NC
NC 93
NC 92
GND 91
GPS_ANT 90
GND 89
101 NC
42 VBAT
41 GND
40 RF ANT
39 GND
38 GND
37 GND
36 NC
35 GND
34 CTS
33 RTS
32 TXD
31 RXD
1 VBAT
43 GND
76 GND
75 SDA
74 SCL
73 GND
72 GND
71 GND
70 DCD
69 DTR
68 RI
30 PCM_OUT
2 GND
44 GND
67 GND
29 PCM_CLK
3 GPIO1
45 GND
77 GND
86 GND
85 GND
84 GND
66 PCM_IN
28 GPIO3
4 STATUS
46 NC
65 PCM_SYNC
27 GPIO2
5 RF_SYNC
47 NC
78 GND
87 GND
88 GND
83 GND
64 NETLIGHT
26 PWM
6 GND
48 PWRKEY
63 NC
25 NC
7 VBUS
49 RESET
79 GND
80 GND
81 GND
82 GND
62 NC
24 NC
8 GND
50 ADC
61 NC
23 NC
9 NC
51 NC
52 NC
53 NC
54 SIM_DET
55 SIM_CLK
56 NC
57 NC
58 GND
59 USB_DP
60 NC
22 DBG_RX
10 NC
11 NC
12 NC
13 NC
14 SIM_DATA
15 SIM_RST
16 SIM_VDD
17 NC
18 VDD_EXT
19 USB_DN
20 BOOT_CFG
21 DBG_TX
94 NC
95 NC
96 NC
97 NC
98 NC
99 NC
103 NC
100 NC

Figure 2: Pin assignment overview

2.2 Pin Description

Table 3: IO parameters definition

Pin type	Description
PI	Power input
PO	Power output
AI	Analog input
AIO	Analog input/output
I/O	Bidirectional input /output
DI	Digital input
DO	Digital output
DOH	Digital output with high level
DOL	Digital output with low level
PU	Pull up
PD	Pull down

Table 4: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VBAT	1,42	I	Power supply	Power supply voltage 3.0～4.3V
VDD_EXT	18	O	1.8V power output	If these pins are unused, keep open.
GND	2,6,8,35,37,38,39,41,43,44,45,58,67,71,72,73,76,77,78,79,80,81,82,83,84,85,86,87,88,89,91		Ground	GND for VBAT recommend to use 2,43,44,45pin
Power on/down				
PWRKEY	48	I	System power on/off control input, active low. The efficient input level must be below 0.5V.	The level is 0.8V when this PIN is floating;
PCM interface				
PCM_CLK	29	O	PCM interface for digital audio	If these pins are unused,

PCM_OUT	30	O		keep open.
PCM_SYNC	65	O		
PCM_IN	66	I		
GPIO				
GPIO1	3	I/O	Programmable general purpose input and output	
GPIO2	27	I/O		
GPIO3	28	I/O		
NETLIGHT	64	O	Network status	
STATUS	4	O	Power on status	
Serial port				
DTR	69	I	Data terminal ready	If these pins are unused, keep open.
RI	68	O	Ring indicator	
DCD	70	O	Data carrier detect	
CTS	34	O	Request to send	
RTS	33	I	Clear to send	
TXD	32	O	Transmit data	
RXD	31	I	Receive data	
Debug interface				
VBUS	7	I	Valid USB detection input with 3.5~5.25V detection voltage	Software download interface.
USB_DP	59	I/O	Positive line of the differential, bi-directional USB signal.	
USB_DN	19	I/O	Negative line of the differential, bi-directional USB signal.	
DBG_TX	21	O	Module log output for SW debug. (only used for platform)	Reserve a test point for it.
DBG_RX	22	I		
ADC				
ADC	50	I	Analog-digital converter input. voltage range: 0～VBAT.	If unused, keep them open.
PWM				
PWM	26	O	Pulse-width modulation	If these pins are unused, keep open.
I2C				
SDA	75	I/O	Open drain output	If these pins are unused, keep open.
SCL	74	O	Open drain output	
SIM card interface				
SIM_VDD	16	O	Voltage supply for SIM card. Support 1.8V or 3V SIM card	All signals of SIM interface should be protected against ESD with a TVS diode array.
SIM_DATA	14	I/O	SIM data input/output	
SIM_CLK	55	O	SIM clock	
SIM_RST	15	O	SIM reset	

SIM_DET	54	DI	SIM card detecting input.	If used, keep a 10k Ω resistor pulling up to the VDD_EXT
Antenna interface				
RF_ANT	40	I/O	Connect GSM/NB antenna	
GPS_ANT	90	I/O	Connect GPS antenna	
Synchronizing signal of RF				
RF_SYNC	5	O	Synchronizing signal of GSM RF signal	
Other				
RESET	49	I	Reset input(Active low)	
BOOT_CFG	20	DI, PD	If it needs to enter into forced USB download mode, it must be pulling up this pin to VDD_EXT before press the PWRKEY. If it needs to boot up normally, please keep this pin open.	Reserve a test points for it. Keep it open. ***DO NOT PULL UP DURING NORMAL POWER UP!***
NC	9,10,11,12,13,17, 23,24,25,36,46, 47,51,52,53,56,57 ,60,61,62,63,92, 93,94,95,96,97,98 ,99,100,101,102, 103	-	Unconnected	KEEP OPEN

Note: Please reserve test points for BOOT_CFG, VDD_EXT and DBG_TX. If there is no USB connector, please also reserve a test point for USB_VBUS, USB_DP, and USB_DM for Firmware upgrade.

2.3 Mechanical Information

The following figure shows the package outline drawing of HERACLES 224G.

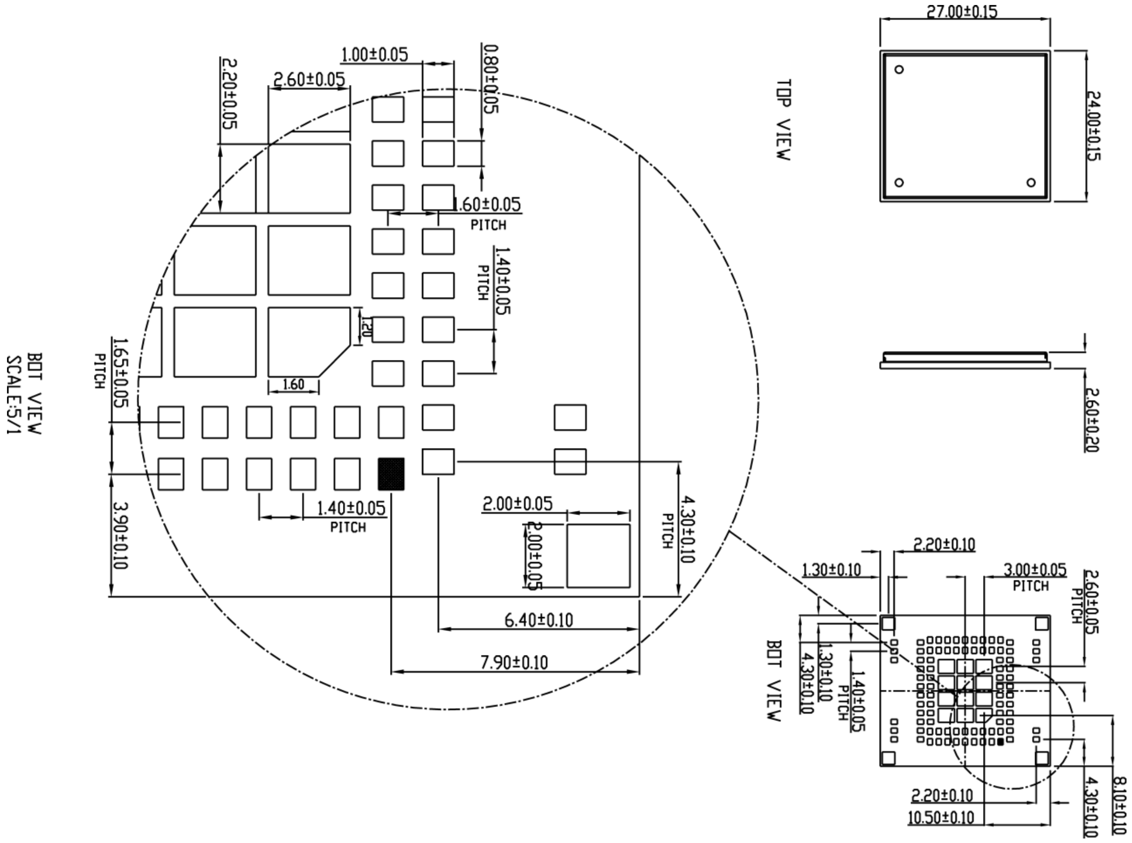

TOP VIEW
27.00±0.15
24.00±0.15
2.60±0.20
BOT VIEW
SCALE:5/1
1.00±0.05
0.80±0.05
2.60±0.05
2.20±0.05
1.60±0.05
PITCH
1.40±0.05
PITCH
1.20
1.60
1.65±0.05
PITCH
1.40±0.05
PITCH
3.90±0.10
2.00±0.05
2.00±0.05
4.30±0.10
PITCH
6.40±0.10
7.90±0.10
BOT VIEW
2.20±0.10
1.30±0.10
3.00±0.05
PITCH
2.60±0.05
PITCH
1.30±0.10
4.30±0.10
1.40±0.05
PITCH
2.20±0.10
10.50±0.10
8.10±0.10
4.30±0.10

Figure 3: Dimensions (Unit: mm)

2.4 Footprint Recommendation

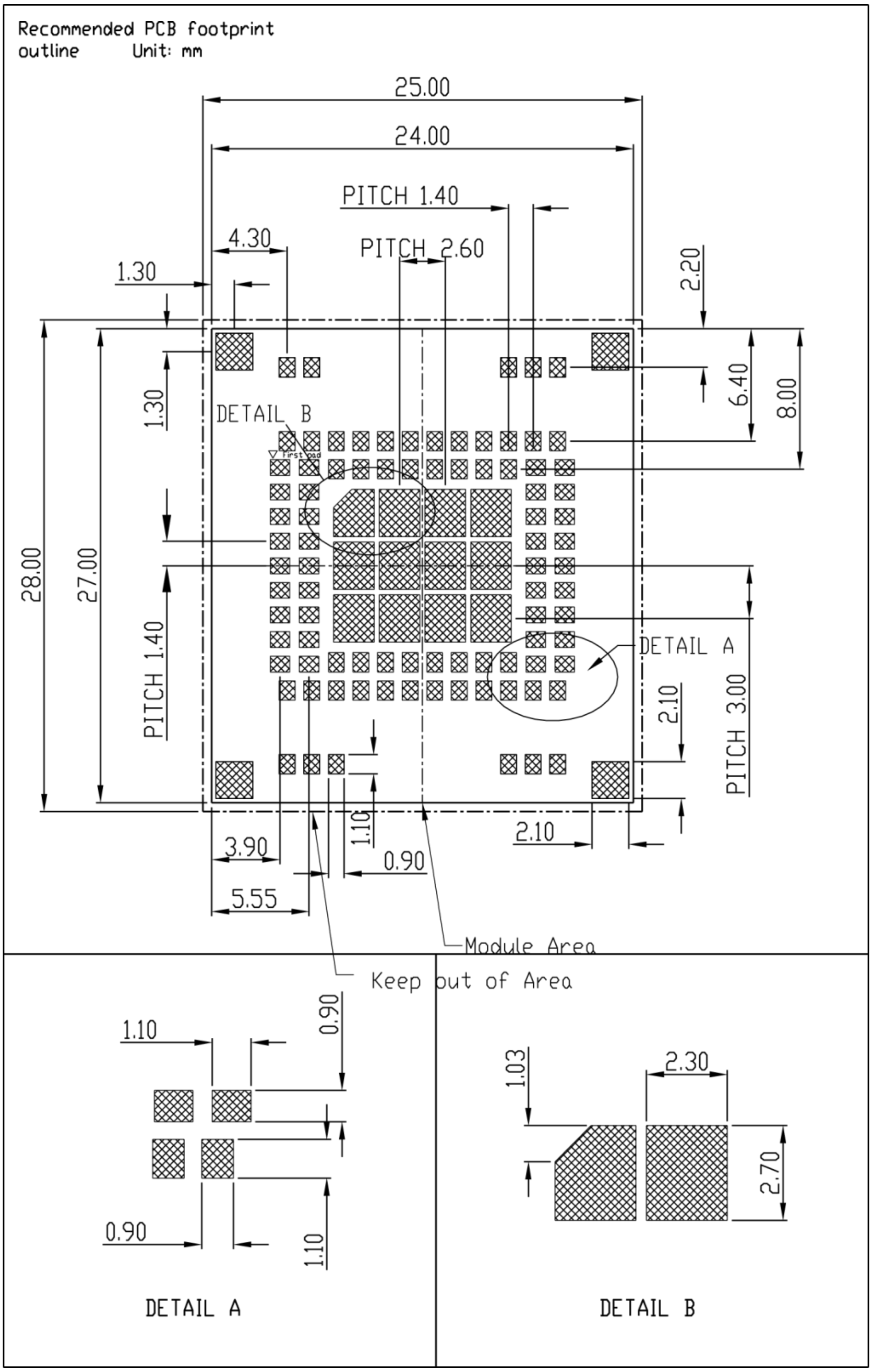

Recommended PCB footprint
outline Unit: mm
25.00
24.00
PITCH 1.40
PITCH 2.60
4.30
1.30
2.20
1.30
6.40
8.00
DETAIL B
First pad
28.00
27.00
PITCH 1.40
DETAIL A
2.10
PITCH 3.00
3.90
1.10
0.90
2.10
5.55
Module Area
Keep out of Area
1.10
0.90
0.90
1.10
DETAIL A
1.03
2.30
2.70
DETAIL B

Figure 4: Footprint recommendation (Unit: mm)

3 Interface Application

3.1 Power Supply

Pin 1 and pin 42 are VBAT power input.

On VBAT pads, when module works on CAT-M1 or NB-IoT mode, the ripple current is up to 0.6A typically. For steady voltage, the power supply capability must be up to 0.6A.

On VBAT pads, when module works on EDGE or GPRS mode, he ripple current is up to 2A typically. For steady voltage, the power supply capability must be up to 2A. In order to avoid the voltage dropped down more than 300mV, the load capacitor on VBAT pads must be up to 300uF.

Note: The test condition: The voltage of power supply for VBAT is 3.8V, Ca=100 μF tantalum capacitor (ESR=0.7Ω) and Ce =100nF (Please refer to Figure 6—Application circuit).

Table 5: VBAT pins electronic characteristic

Symbol	Description	Min.	Typ.	Max.	Unit
VBAT	Module power voltage	3.0	3.8	4.3	V
$I_{VBAT(peak)}$	Module power peak current in GSM and EDGE emission mode.	-	2	-	A
	Module power peak current in CAT-M1 and NB-IoT emission mode.	-	0.6	-	A
$I_{VBAT(average)}$	Module power average current in normal mode	Please refer to the chapter 5.4			
$I_{VBAT(sleep)}$	Power supply current in sleep mode				
$I_{VBAT(power\text{-}off)}$	Module power current in power off mode.	-	-	7	uA

3.1.1 Power Supply Design Guide

Make sure that the voltage on the VBAT pins will never drop below 3.0V, even during a transmit burst when current consumption may rise up to 2A. If the voltage drops below 3.0V, module will be shutdown.

Note: If the power supply for VBAT pins can support up to 2A, using a total of more than 300uF capacitors is recommended, or else users must using a total of 1000uF capacitors typically, in order to avoid the voltage drop is more than 300mV.

Some multi-layer ceramic chip (MLCC) capacitors (0.1uF, 1uF) with low ESR in high frequency band can be used for EMC.

These capacitors should be put as close as possible to VBAT pads. Also, users should keep VBAT trace on circuit board wider than 2 mm to minimize PCB trace impedance. The following figure shows the recommended circuit.

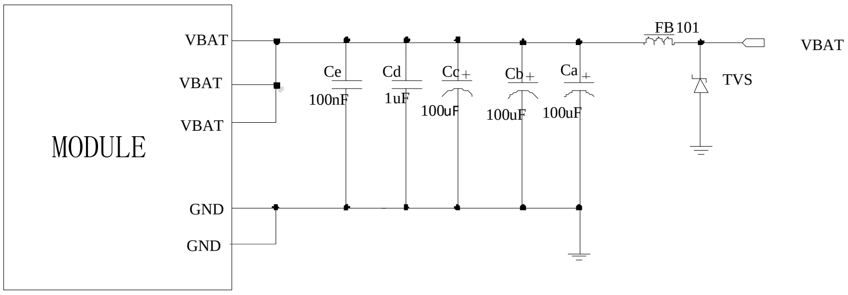

MODULE
VBAT
VBAT
VBAT
GND
GND
Ce
100nF
Cd
1uF
Cc
100uF
Cb
100uF
Ca
100uF
FB101
VBAT
TVS

Figure 5: Power supply application circuit

In addition, for ESD protection, it is suggested to add a TVS diode near the VBAT PINs.

Table 6: Recommended TVS diode list

No.	Manufacturer	Part Number	Package
1	Prisemi	PESDHC2FD4V5B	DFN1006
2	Prisemi	PESDHC3D3V3U	SOD323
3	WILLsemi	ESD5651N-2/TR	DFN1006

3.1.2 Recommended Power Supply Circuit

In order to meet the requirements of the above power supply, It is recommended to use a DCDC with large output current and small quiescent current, the part number is TPS62088 of TI.

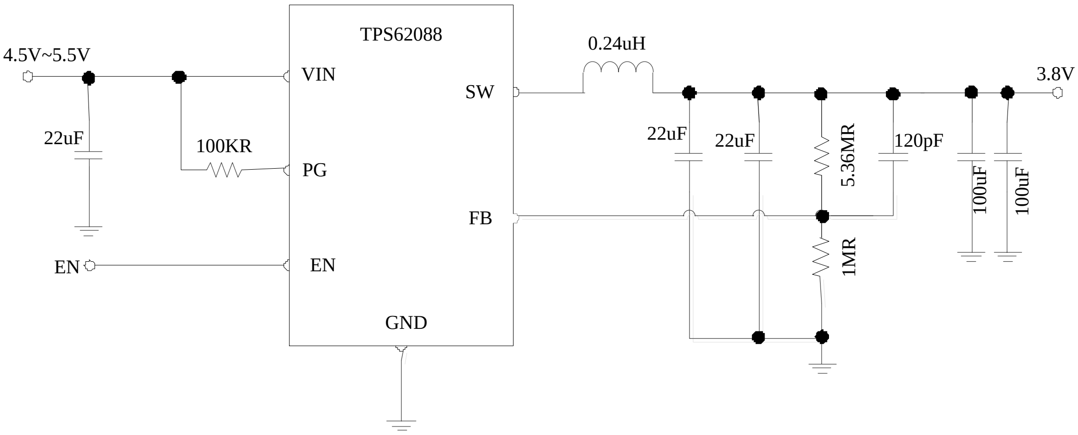

TPS62088
4.5V~5.5V
VIN
SW
0.24uH
3.8V
22uF
100KR
PG
FB
EN
EN
GND
22uF
22uF
5.36MR
120pF
100uF
100uF
1MR

Figure 6: power supply reference circuit

3.1.3 Voltage Monitor

To monitor the VBAT voltage, the AT command “AT+CBC” can be used.

AT command “AT+CBATCHK=1” can be used to enable the overvoltage warning function and the under-voltage warning function. The default value of the overvoltage warning function in the software is 4.3V, and the default value of the under-voltage warning function is 3.1V. If the power supply for VBAT pins is up 4.3V or under 3.1V, module will be warning.

The AT command “AT+CBATCHK=1” also can be used to enable the overvoltage power-off function and the under-voltage power-off function. The default value of the overvoltage power-off function is 4.4V, and the default value of the under-voltage power-off function is 2.9V. If the VBAT voltage is up 4.4V or under 2.9V, module will be power off.

Note: Under-voltage warning function and under-voltage power-off function are disabled by default. For more information about these AT commands, please refer to Document [1].

3.2 Power on/Power off/Reset Function

3.2.1 Power on

HERACLES 224G can be powered on by pulling the PWRKEY pin to ground.

The PWRKEY pin has been pulled up with a diode to 1.8V internally, so it does not need to be pulled up externally. It is strongly recommended to put a 100nF capacitor and an ESD protection diode close to the PWRKEY pin, as it would strongly enhance the ESD performance of PWRKEY pin. Please refer to the following figure for the recommended reference circuit.

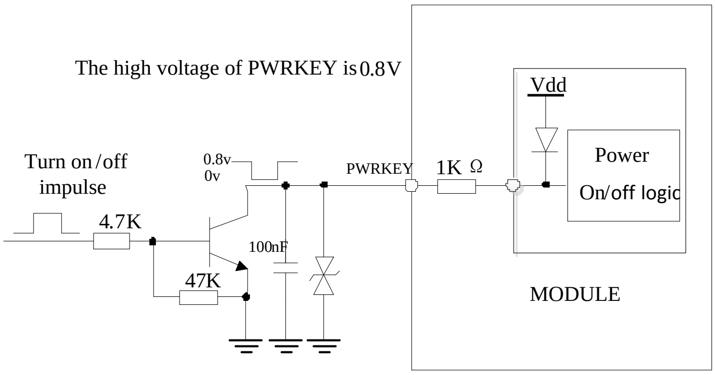

The high voltage of PWRKEY is 0.8V
Vdd
Turn on/off impulse
0.8v
0v
PWRKEY
1K Ω
Power On/off logic
4.7K
100nF
47K
MODULE

Figure 7: Reference power on/off circuit

The power-on scenarios are illustrated in the following figure.

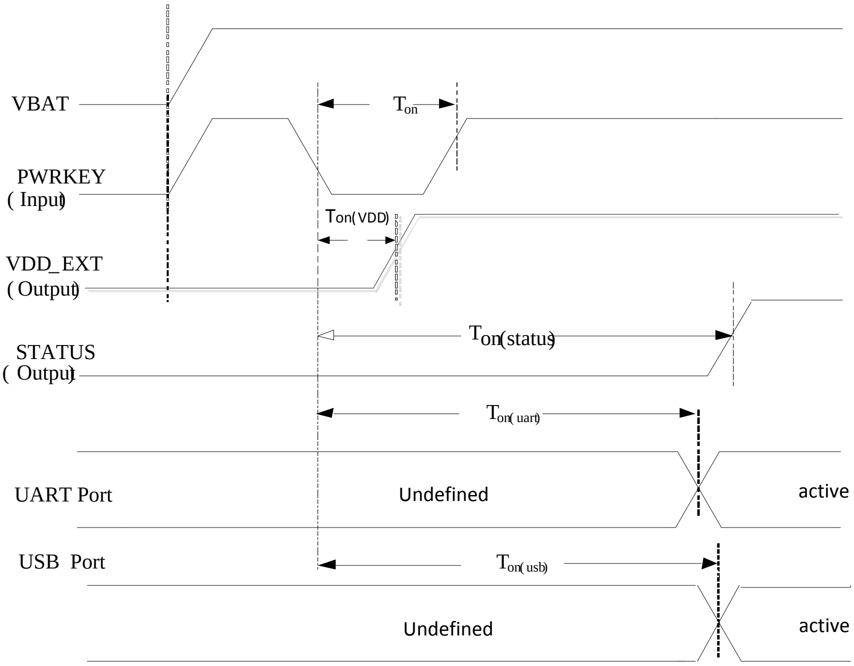

VBAT
Ton
PWRKEY (Input)
Ton(VDD)
VDD_EXT (Output)
Ton(status)
STATUS (Output)
Ton(uart)
UART Port
Undefined
active
USB Port
Ton(usb)
Undefined
active

Figure 8: Power on timing sequence

Table 7: Power on timing and electronic characteristic

Symbol	Parameter	Min.	Typ.	Max.	Unit
T_{on}	The time of active low level impulse of PWRKEY pin to power on module	1	-	-	s
$T_{on(Vdd)}$	The time from power-on issue to VDD_EXT pin output high level.		64		ms
$T_{on(status)}$	The time from power-on issue to STATUS pin output high level(indicating power up ready)	4.5	-	-	s
$T_{on(uart)}$	The time from power-on issue to UART port ready	4.5	-	-	s
$T_{on(usb)}$	The time from power-on issue to USB port ready	4.5	-	-	s
V_{IH}	Input high level voltage on PWRKEY pin	0.6	0.8	1.8	V
V_{IL}	Input low level voltage on PWRKEY pin	-0.3	0	0.5	V

3.2.2 Power off

The following methods can be used to power off HERACLES 224G.

- Method 1: Power off HERACLES 224G by pulling the PWRKEY pin to ground.
- Method 2: Power off HERACLES 224G by AT command “AT+CPOWD=1”.
- Method 3: over-voltage or under-voltage automatic power off. The function can be enabled by AT command “AT+CBATCHK=1”. Default is disabled.

Note: For details about “AT+CPOWD” and “AT+CBATCHK”, please refer to Document [1].

These procedures will make modules disconnect from the network and allow the software to enter a safe state, and save data before module be powered off completely.

The power off scenario by pulling down the PWRKEY pin is illustrated in the following figure.

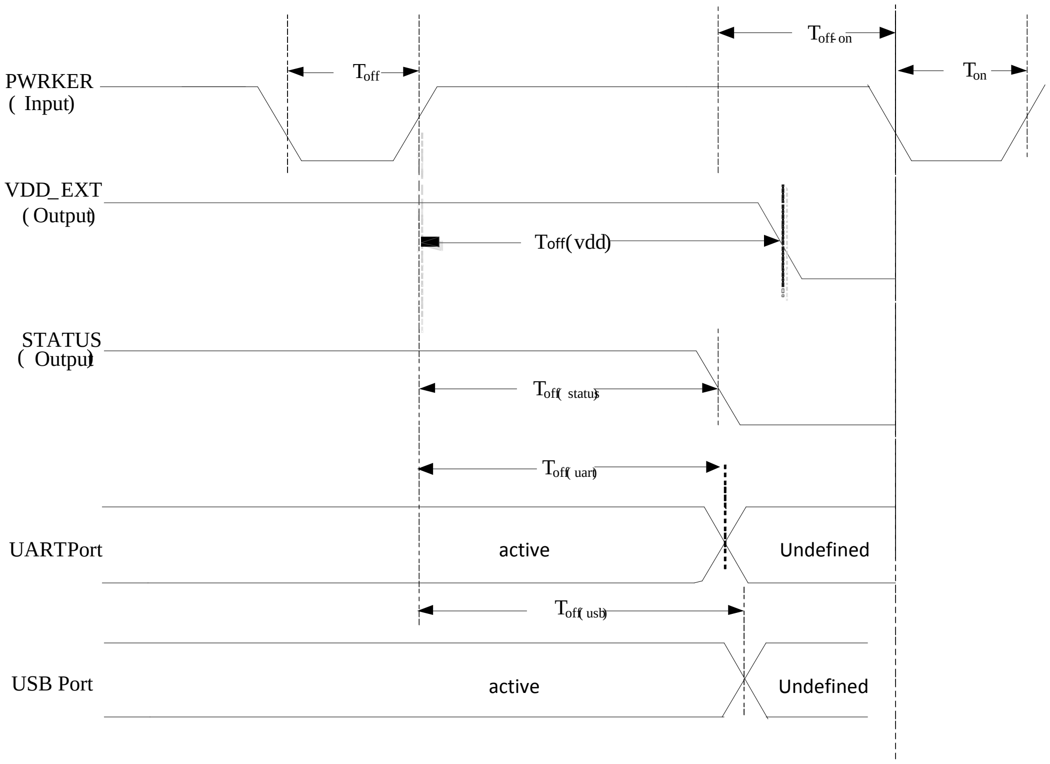

PWRKER (Input)
VDD_EXT (Output)
STATUS (Output)
UARTPort
USB Port
Toff
Toff-on
Ton
Toff(vdd)
Toff(status)
Toff(uart)
Toff(usb)
active
Undefined
active
Undefined

Figure 9: Power off timing sequence

Table 8: Power off timing and electronic characteristic

Symbol	Parameter	Time value			Unit
		Min.	Typ.	Max.	
T_{off}	The active low level time pulse on PWRKEY pin to power off module	1.2	-	-	s
$T_{off(vdd)}$	The time from power-off issue to VDD_EXT pin output low level	1.8	-	6.9	s
$T_{off(status)}$	The time from power-off issue to STATUS pin output low level(indicating power off)*	1.8	-	6.9	s
$T_{off(uart)}$	The time from power-off issue to UART port off	1.8	-	6.9	s
$T_{off(usb)}$	The time from power-off issue to USB port off	1.8	-	6.9	s
T_{off-on}	The buffer time from power-off issue to power-on issue	2	-	-	s

Note: The STATUS pin can be used to detect whether module is powered on or not. When module has been powered on and firmware goes ready, STATUS will be high level, or else STATUS will still low level.

3.2.3 Reset Function

HERACLES 224G can be reset by pulling the RESET pin to ground.

Note: This function is only used as an emergency reset. The RESET pin will be ineffectiveness in the power off mode.

The RESET pin has been pulled up to 1.8V with a 40KΩ resistor internally. So it does not need to be pulled up externally. It is strongly recommended to put a100nF capacitor and an ESD protection diode close to the RESET pin. Please refer to the following figure for the recommended reference circuit.

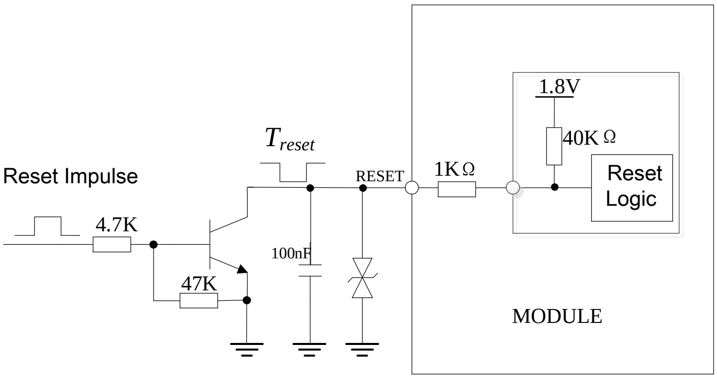


Figure 10: Reference reset circuit

Table 9: RESET pin electronic characteristic

Symbol	Description	Min.	Typ.	Max.	Unit
T_{reset}	The active low level time impulse on RESET pin to reset module	252			ms
V_{IH}	Input high level voltage	1.2	1.8	2.1	V
V_{IL}	Input low level voltage	-0.3	0	0.8	V

3.3 UART Interface

HERACLES 224G provides a 7-wire UART (universal asynchronous serial transmission) interface as DCE (Data Communication Equipment). AT commands and data transmission can be performed through this UART interface.

HERACLES 224G support high speed UART, the baud rate is up to 4Mbps. The communication baud rates include:0,300,600,1200,2400,4800,9600,19200,38400,57600,115200,230400,921600,2000000 ,3000000,3200000,3686400 bps. The rate 0bps mark auto baud rate. And it supports auto baud rate, but the rate only supported on 9600, 19200, 38400, 57600, 115200. If users need to change to other baud rate, it needs to switch via manual operation.

3.3.1 UART Design Guide

The following figures show the reference design.

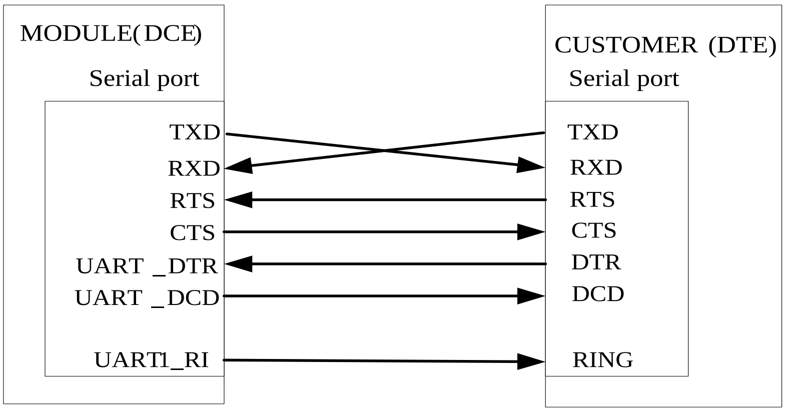

MODULE(DCE)
Serial port
TXD
RXD
RTS
CTS
UART _DTR
UART _DCD
UART1_RI
CUSTOMER (DTE)
Serial port
TXD
RXD
RTS
CTS
DTR
DCD
RING

Figure 11: UART full modem

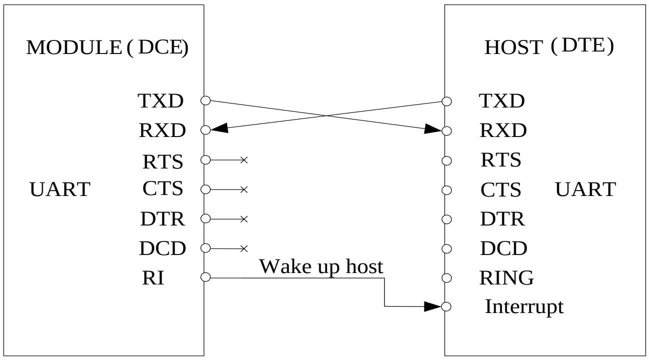

MODULE(DCE)
UART
TXD
RXD
RTS
CTS
DTR
DCD
RI
Wake up host
HOST(DTE)
TXD
RXD
RTS
CTS
DTR
DCD
RING
Interrupt
UART

Figure 12: UART null modem

Table 10: UART electronic characteristic

Symbol	Description	Min.	Typ.	Max.	Unit
V_{IH}	UART input high level voltage	1.17	1.8	2.1	V
V_{IL}	UART input low level voltage	-0.3	0	0.63	V
V_{OH}	UART output high level voltage	1.35	1.8	1.8	V
V_{OL}	UART output low level voltage	0	0	0.45	V

The HERACLES 224G UART is 1.8V voltage interface. If user's UART application circuit is 3.3V voltage interface, the level shifter circuits should be used for voltage matching. The following figure shows the voltage matching reference design.

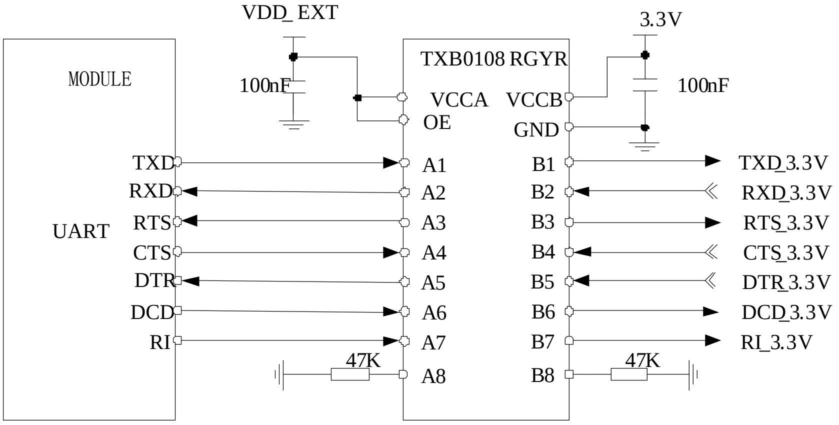

VDD_EXT
3.3V
MODULE
TXB0108 RGYR
100nF
100nF
VCCA
VCCB
OE
GND
UART
TXD
RXD
RTS
CTS
DTR
DCD
RI
A1
A2
A3
A4
A5
A6
A7
A8
B1
B2
B3
B4
B5
B6
B7
B8
TXD_3.3V
RXD_3.3V
RTS_3.3V
CTS_3.3V
DTR_3.3V
DCD_3.3V
RI_3.3V
47K
47K

Figure 13: Reference circuit of level shift

Note: When it uses the level shifter IC, the pull up resistance on TXD_3.3V, RTS_3.3V, DCD_3.3V and RI_3.3V should not be less than 47K Ω.

3.3.2 RI and DTR Behavior

The RI pin description:

The RI pin can be used to interrupt output signal to inform the host controller such as application CPU. Before that, users must use AT command "AT+CFGRI=1" to enable this function.

Normally RI will keep high level until certain conditions such as receiving SMS, or a URC report coming, then it will output a low level pulse 120ms, in the end, it will become high level.

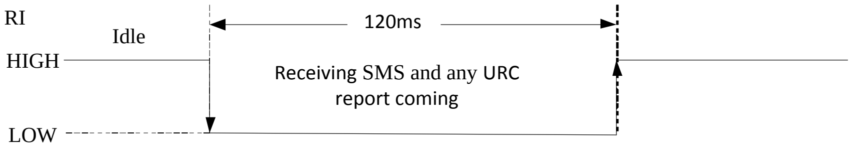

RI
Idle
HIGH
LOW
120ms
Receiving SMS and any URC report coming

Figure 14: RI behaviour（SMS and URC report）

The DTR pin description:

After setting the AT command "AT+CSCLK=1", and then pulling up the DTR pin, HERACLES 224G will enter sleep mode when module is in idle mode. In sleep mode, the UART is unavailable.

When HERACLES 224G enters sleep mode, pulling down DTR can wake up module.

After setting the AT command “AT+CSCLK=0”, HERACLES 224G will do nothing when the DTR pin is pulling up.

Note: For more details of AT commands about UART, please refer to document [1] and [20].

3.4 USB Interface

The HERACLES 224G contains a USB interface compliant with the USB2.0 specification as a peripheral, but the USB charging function is not supported.
USB_VBUS is the detecting signal for USB inserting. The input voltage range on the USB_VBUS pin is from 3.5V to 5.25V. If there is out of this range, it may be due to USB function unidentifiable, even damaging the module.

The reference circuit refers to the following figure.

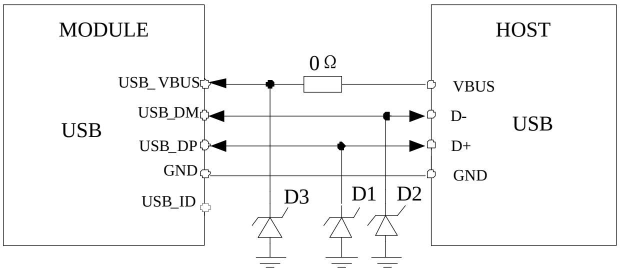


Figure 15: USB reference circuit

Because of the high speed on USB bus, more attention should be paid to the influence of the junction capacitance of the ESD component on USB data lines. Typically, the capacitance of the D1 and D2 should be less than 1pF.
D3 is suggested to select the diode with anti-ESD and voltage surge function, or customer could add a ZENER diode for surge clamping.
Note：The USB_DM and USB_DP nets must be traced by 90Ohm+/-10% differential impedance.

3.5 SIM Interface

HERACLES 224G supports dual SIM card functions. One is patch eSIM card. The other is SIM card interface. They support both 1.8V and 3.0V SIM Cards.

Table 11: SIM electronic characteristic in 1.8V mode (SIM_VDD=1.8V)

Symbol	Parameter	Min.	Typ.	Max.	Unit
SIM_VDD	LDO power output voltage	1.75	1.8	1.95	V
V_{IH}	High-level input voltage	0.65*SIM_VDD	-	SIM_VDD +0.3	V
V_{IL}	Low-level input voltage	-0.3	0	0.35*SIM_VDD	V
V_{OH}	High-level output voltage	SIM_VDD -0.45	-	SIM_VDD	V
V_{OL}	Low-level output voltage	0	0	0.45	V

Table 12: SIM electronic characteristic 3.0V mode (SIM_VDD=2.95V)

Symbol	Parameter	Min.	Typ.	Max.	Unit
SIM_VDD	LDO power output voltage	2.75	2.95	3.05	V
V_{IH}	High-level input voltage	0.65*SIM_VDD	-	SIM_VDD +0.3	V
V_{IL}	Low-level input voltage	-0.3	0	0.25*SIM_VDD	V
V_{OH}	High-level output voltage	SIM_VDD -0.45	-	SIM_VDD	V
V_{OL}	Low-level output voltage	0	0	0.45	V

3.5.1 SIM Application Guide

It is recommended to use an ESD protection component such as ESDA6V1W5 produced by ST (www.st.com) or SMF15C produced by ON SEMI (www.onsemi.com). Note that the SIM peripheral circuit should be close to the SIM card socket. The following figure shows the 6-pin SIM card holder reference circuit.

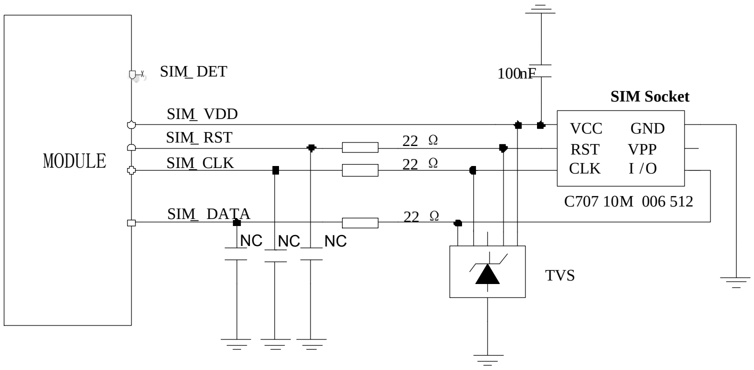


Figure 16: SIM interface reference circuit

SIM_DATA has been pulled up with a 10KΩ resistor to SIM_VDD in module, so it no need pulled up resistor anymore.

SIM_VDD is need a 100nF capacitor close to SIM socket.

SIM_CLK is very important signal, the rise time and fall time of SIM_CLK should be less than 40ns. So the junction capacity of the TVS need to less 50pF.

SIM_DET is the detecting signal for SIM card to insert and pull out. There is no pull up resistor in module, so a 10KΩ resistor is necessary to pulling up to the power VDD_EXT. This function is disabled default by software. Users can enable it by AT comment “AT+CSDT”. And the Interruption direction can be set by AT comment “AT+CSPOL”.

Note：For more details of AT commands about “AT+CSDT” and “AT+CSPOL”, please refer to document [1]

3.6 PCM Interface

HERACLES 224G provides a PCM interface for external codec, which can be used in master mode with short sync and 16 bits linear format.

Table 13: PCM format

Characteristics	**Specification**
Line Interface Format	Linear(Fixed)
Data length	16bits(Fixed)
PCM Clock/Sync Source	Master Mode(Fixed)
PCM Clock Rate	2048 KHz (Fixed)
PCM Sync Format	Short sync(Fixed)
Data Ordering	MSB

Note: For more details about PCM AT commands, please refer to document [1].

3.6.1 PCM timing

HERACLES 224G supports 2.048 MHz PCM data and sync timing for 16 bits linear format codec.

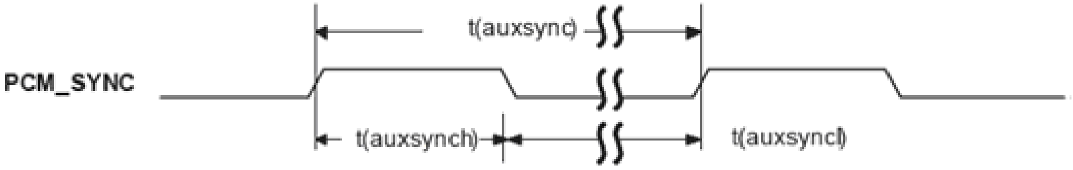

t(auxsync)
PCM_SYNC
t(auxsynch)
t(auxsyncl)

Figure 17: PCM_SYNC timing

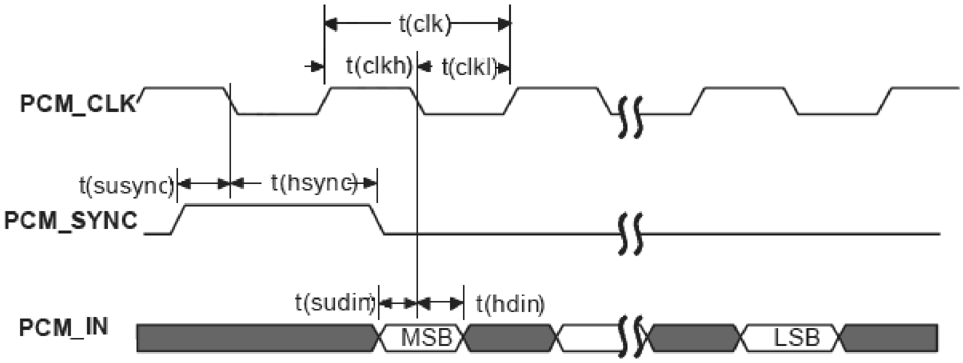

t(clk)
t(clkh)
t(clkl)
PCM_CLK
t(susync)
t(hsync)
PCM_SYNC
t(sudin)
t(hdin)
PCM_IN
MSB
LSB

Figure 18: External codec to module timing

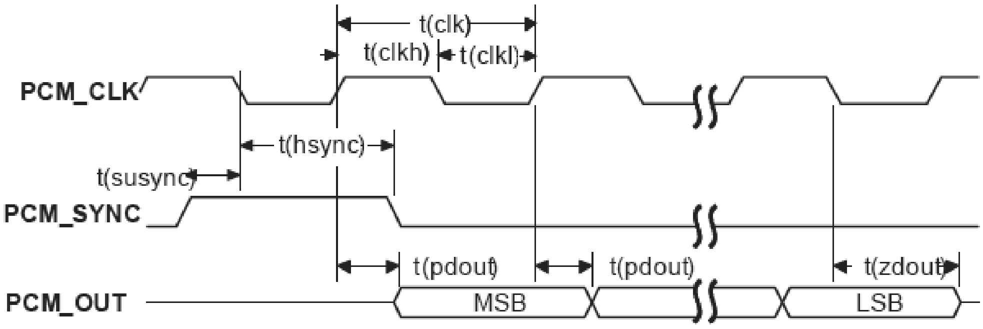

t(clk)
t(clkh)
t(clkl)
PCM_CLK
t(hsync)
t(susync)
PCM_SYNC
t(pdout)
t(pdout)
t(zdout)
PCM_OUT
MSB
LSB

Figure 19: Module to external codec timing

Table 14: PCM timing parameters

Parameter	Description	Min.	Typ.	Max.	Unit
T(sync)	PCM_SYNC cycle time	–	125	–	μs
T(synch)	PCM_SYNC high level time	–	488	–	ns
T(syncl)	PCM_SYNC low level time	–	124.5	–	μs
T(clk)	PCM_CLK cycle time	–	488	–	ns
T(clkh)	PCM_CLK high level time	–	244	–	ns
T(clkl)	PCM_CLK low level time	–	244	–	ns
T(susync)	PCM_SYNC setup time high before falling edge of PCM_CLK	–	122	–	ns
T(hsync)	PCM_SYNC hold time after falling edge of PCM_CLK	–	366	–	ns
T(sudin)	PCM_IN setup time before falling edge of PCM_CLK	60	–	–	ns
T(hdin)	PCM_IN hold time after falling edge of PCM_CLK	60	–	–	ns
T(pdout)	Delay from PCM_CLK rising to PCM_OUT valid	–	–	60	ns
T(zdout)	Delay from PCM_CLK falling to PCM_OUT HIGH-Z	–	–	60	ns

3.6.2 PCM Application Guide

The following figure shows the external codec reference design.

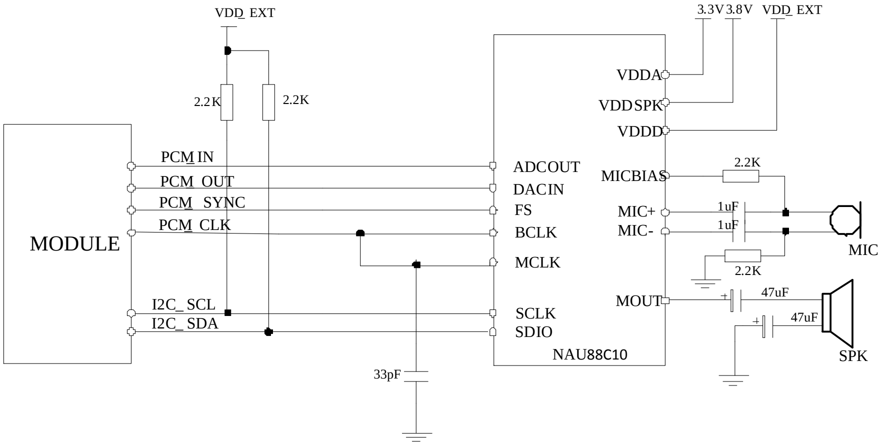

VDD_EXT
2.2K
2.2K
MODULE
PCM IN
PCM_OUT
PCM_SYNC
PCM_CLK
I2C_SCL
I2C_SDA
33pF
ADCOUT
DACIN
FS
BCLK
MCLK
SCLK
SDIO
NAU88C10
VDDA
VDDSPK
VDDD
MICBIAS
MIC+
MIC-
MOUT
3.3V
3.8V
VDD_EXT
2.2K
1uF
1uF
2.2K
47uF
47uF
MIC
SPK

Figure 20: Audio codec reference circuit

3.7 I2C Interface

HERACLES 224G provides an I2C interface compatible with I2C specification, version 5.0, with clock rate up to 400 kbps. Its operation voltage is 1.8V.

The following figure shows the I2C bus reference design.

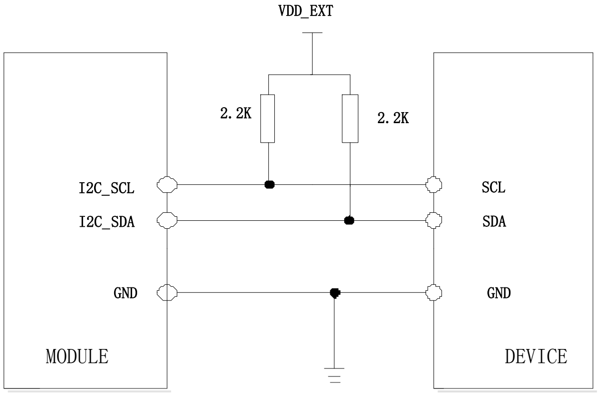

VDD_EXT
2.2K
2.2K
I2C_SCL
I2C_SDA
GND
MODULE
SCL
SDA
GND
DEVICE

Figure 21: I2C reference circuit

The I2C signal has no pull-up resistors in module. So the pulling up resistors 2.2KΩ to VDD_EXT are necessary in application circuit.

3.8 Network status

The NETLIGHT pin is used to control Network Status LED, its reference circuit is shown in the following figure.

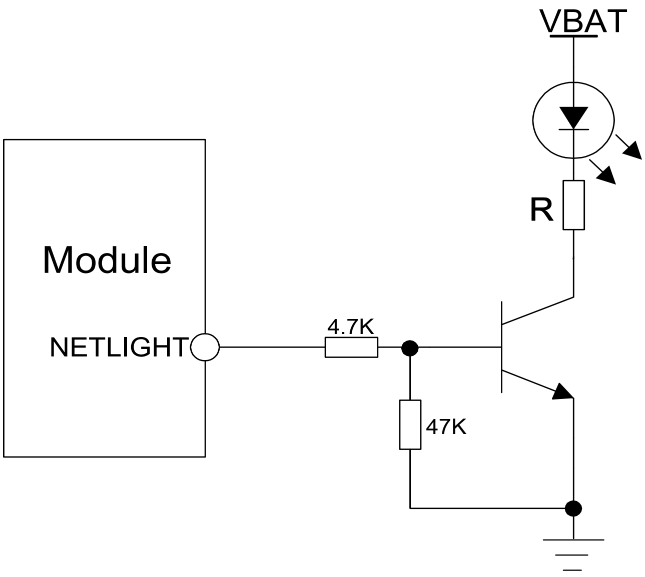


Figure 22: NETLIGHT reference circuit

Note: The value of the resistor named "R" depends on the LED characteristic.

Table 15: NETLIGHT pin status

NETLIGHT pin status	**Module status**
64ms ON, 800ms OFF	No registered network
64ms ON, 3000ms OFF	Registered network (PS domain registration success)
64ms ON, 300ms OFF	Data transmit (PPP dial-up state and use of data services such as internal TCP/FTP/HTTP)
OFF	Power off or PSM mode

Note: NETLIGHT output low level as "OFF" and high level as "ON".

3.9 Other interface

3.9.1 ADC

HERACLES 224G has a dedicated ADC pin. It is available for digitizing analog signals such as battery voltage and so on. Its input voltage range is from 0V to VBAT. That is the maximum measurement range of ADC cannot exceed the input voltage of VBAT (3V~4.3V). When the voltage of the VBAT is reduced during use, the range of ADC will also be reduced. If the input voltage of ADC PIN exceeds its range, it is necessary to implement the resistance partial pressure on the hardware

The electronic specifications are shown in the following table.

Table 16: ADC electronic characteristics

Characteristics	Min.	Typ.	Max.	Unit
Resolution	–	–	15	Bits
Input Range	0		VBAT	V
Input serial resistance	1	–	–	MΩ

Note: "AT+CADC" can be used to read the voltage of the ADC pin, for more details, please refer to document [1].

3.9.2 LDO

HERACLES 224G has a LDO power output named VDD_EXT. The output voltage is 1.8V. This voltage can only be pulled up for the external GPIO or power supply for the level conversion circuit.

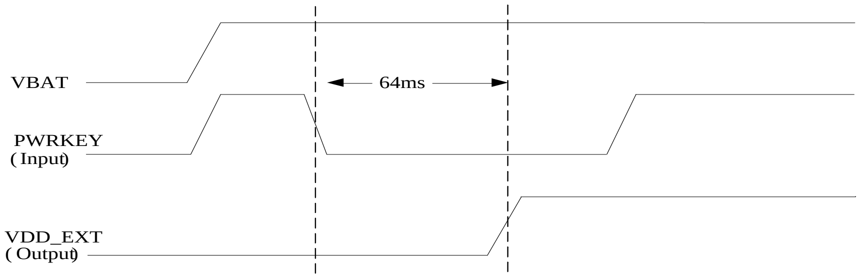


Figure 23: Power on sequence of the VDD_EXT

Table 17: Electronic characteristic

Symbol	Description	Min.	Typ.	Max.	Unit
V_{VDD_EXT}	Output voltage	1.7	1.8	1.9	V
I_O	Output current	-	-	50	mA

Note：The VDD_EXT is used to the IO power in the module. The Output voltage is not

supported to adjust.

4 RF Specifications

4.1 GSM/LTE RF Specifications

Table 18: Conducted transmission power

Frequency	Power	Min.
GSM850	33dBm ±2dB	5dBm ±5dB
EGSM900	33dBm ±2dB	5dBm ±5dB
DCS1800	30dBm ±2dB	0dBm ±5dB
PCS1900	30dBm ±2dB	0dBm ±5dB
LTE-FDD B1	23dBm +/-2.7dB	<-40dBm
LTE-FDD B2	23dBm +/-2.7dB	<-40dBm
LTE-FDD B3	23dBm +/-2.7dB	<-40dBm
LTE-FDD B4	23dBm +/-2.7dB	<-40dBm
LTE-FDD B5	23dBm +/-2.7dB	<-40dBm
LTE-FDD B6	23dBm +/-2.7dB	<-40dBm
LTE-FDD B8	23dBm +/-2.7dB	<-40dBm
LTE-FDD B12	23dBm +/-2.7dB	<-40dBm
LTE-FDD B13	23dBm +/-2.7dB	<-40dBm
LTE-FDD B18	23dBm +/-2.7dB	<-40dBm
LTE-FDD B19	23dBm +/-2.7dB	<-40dBm
LTE-FDD B20	23dBm +/-2.7dB	<-40dBm
LTE-FDD B26	23dBm +/-2.7dB	<-40dBm
LTE-FDD B28	23dBm +/-2.7dB	<-40dBm
LTE-FDD B39	23dBm +/-2.7dB	<-40dBm

**** Note：The max power is tested result for 1RB in CAT-M1 and single-tone in CAT-NB1. MPR for CAT-M1 please refer to 6.2.3EA.5 part for 3GPP. Multi-tone test results please refer to part 6.2.3F.3 for CAT-NB1.***

Table 19: Maximum Power Reduction (MPR) for UE category NB1 Power Class 3

Modulation	QPSK		
Tone positions for 3 Tones allocation	0-2	3-5 and 6-8	9-11
MPR	≤ 0.5 dB	0 dB	≤ 0.5 dB
Tone positions for 6 Tones allocation	0-5 and 6-11		
MPR	≤ 1 dB	≤ 1 dB	
Tone positions for 12 Tones allocation	0-11		
MPR	≤ 2 dB		

Table 20: Operating frequencies

Frequency	Receiving	Transmission
GSM850	869~894 MHz	824~849 MHz
EGSM900	925～960MHz	880～915 MHz
DCS1800	1805～1880 MHz	1710～1785 MHz
PCS1900	1930~1990MHz	1850~1910MHz
GPS L1 BAND	1574.4 ～1576.44 MHz	-
GLONASS	1598 ～1606 MHz	-
BD	1559 ～1563 MHz	
LTE BAND	Refers to Table 21	

Table 21: E-UTRA operating bands

E-UTRA	UL Freq.	DL Freq.	Duplex Mode
1	1920 ~1980 MHz	2110 ~2170 MHz	HD-FDD
2	1850~1910MHz	1930~1990MHz	HD-FDD
3	1710 ~1785 MHz	1805 ~1880 MHz	HD-FDD
4	1710~1755 MHz	2110~2155 MHz	HD-FDD
5	824 ~849 MHz	869 ~894 MHz	HD-FDD
8	880 ~915 MHz	925 ~960 MHz	HD-FDD
12	699 ~716 MHz	729 ~746 MHz	HD-FDD
13	777 ~787 MHz	746 ~756 MHz	HD-FDD
17	704~716 MHz	734~746MHz	HD-FDD
18	815 ~830 MHz	860 ~875 MHz	HD-FDD
19	830 ~845 MHz	875 ~890 MHz	HD-FDD
20	832 ~862 MHz	791 ~821 MHz	HD-FDD
26	814 ~849 MHz	859 ~894 MHz	HD-FDD
28	703 ~748 MHz	758 ~803 MHz	HD-FDD
39	1880 ~1920 MHz	1880 ~1920 MHz	TDD

Table 22: Conducted receive sensitivity

Frequency	Receive sensitivity(Typical)	Receive sensitivity(MAX)
GSM850	< -109dBm	3GPP
EGSM900	< -109dBm	3GPP
DCS1800	< -109dBm	3GPP
PCS1900	< -109dBm	3GPP
LTE FDD/TDD	Refers to Table 23	

Table 23: CAT-M1 Reference sensitivity (QPSK)

E-UTRA Band	REFSENS MAX(dBm) 3GPP	REFSENS Typical (dBm)	Duplex Mode
1	-103	-108	HD-FDD
2	-101	-107.5	HD-FDD
3	-100	-108.5	HD-FDD
4	-103	-108	HD-FDD
5	-101.5	-107	HD-FDD
8	-100.5	-107.5	HD-FDD
12	-100	-107	HD-FDD
13	-100	-107	HD-FDD
17	-100	-107	HD-FDD
18	-103	-108	HD-FDD
19	-103	-108	HD-FDD
20	-100.5	-108.5	HD-FDD
26	-101	-107.5	HD-FDD
28	-101.5	-107	HD-FDD
39	-103.7	TBD	TDD

Table 24 : FDD and TDD UE category M1 Uplink configuration for reference sensitivity

E-UTRA Band	N_{RB}	Duplex Mode
1	6^1	FDD and HD-FDD
2	6^1	FDD and HD-FDD
3	6^1	FDD and HD-FDD
4	6^1	FDD and HD-FDD
5	6^1	FDD and HD-FDD
8	6^1	FDD and HD-FDD
12	6^1	FDD and HD-FDD
13	6^1	FDD and HD-FDD
17	6^1	FDD and HD-FDD
18	6^1	FDD and HD-FDD
19	6^1	FDD and HD-FDD
26	6^1	FDD and HD-FDD
28	6^1	FDD and HD-FDD
39	6^1	TDD
NOTE 1: ^{1} refers to the UL resource blocks shall be located as close as possible to the downlink operating band but confined within the transmission bandwidth configuration for the channel bandwidth		

Table 25: CAT-NB1 Reference sensitivity (QPSK)

Operating band	REFSENS (dBm) 3GPP Request	REFSENS Typical(dBm)	REFSENS Typical Repeated 7/128 [EPRE dBm/15KHz]
1, 2, 3, 4,5, 8, 12, 13, 17, 18, 19, 20, 26, 28	-108.2	-114	-145

4.2 GSM/LTE Antenna Design Guide

Users should connect antennas to HERACLES 224G's antenna pads through micro-strip line or other types of RF trace and the trace impedance must be controlled in 50Ω. SIMCom recommends that the total insertion loss between the antenna pads and antennas should meet the following requirements:

Table 25: Trace loss

Frequency	Loss
700MHz-960MHz	<0.5dB
1710MHz-2170MHz	<0.9dB
2300MHz-2650MHz	<1.2dB

To facilitate the antenna tuning and certification test, a RF connector and an antenna matching circuit should be added. The following figure is the recommended circuit.

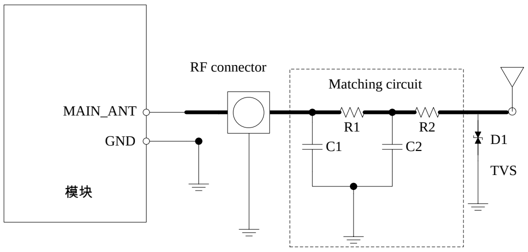


Figure 24: Antenna matching circuit (MAIN_ANT)

In above figure, the components R1, C1, C2 and R2 are used for antenna matching, the values of components can only be achieved after the antenna tuning and usually provided by antenna vendor. By default, the R1, R2 are 0Ω resistors, and the C1, C2 are reserved for tuning. The component D1 is a TVS for ESD protection, and it is optional for users according to application environment.

The RF test connector is used for the conducted RF performance test, and should be placed as close as to the module's MAIN_ANT pin. The traces impedance between HERACLES 224G and antenna must be controlled in 50Ω.

Two TVS are recommended in the table below.

Table 26: Recommended TVS

Package	Part Number	Vender
0201	LXES03AAA1-154	Murata
0402	LXES15AAA1-153	Murata

4.3 GNSS

HERACLES 224G merges GNSS (GPS/GLONASS/BD) satellite and network information to provide a high-availability solution that offers industry-leading accuracy and performance. This solution performs well, even in very challenging environmental conditions where conventional GNSS receivers fail, and provides a platform to enable wireless operators to address both location-based services and emergency mandates.

4.3.1 GNSS Technical specification

- Tracking sensitivity: -162 dBm（GPS）/-157 dBm（GLONASS）/TBD (BD)
- Cold-start sensitivity: -148 dBm
- Accuracy (Open Sky): 2.5m (CEP50)
- TTFF (Open Sky) : Hot start <1s, Cold start<35s
- Receiver Type: 16-channel, C/A Code
- GPS L1 Frequency: 1575.42±1.023MHz
- GLONASS: 1597.5~1605.8 MHz
- BD: 1559.05~1563.14 MHz
- Update rate: Default 1 Hz
- GNSS data format: NMEA-0183
- GNSS Current consumption : 30mA (GSM/LTE Sleep, in total on VBAT pins)
- GNSS antenna: Passive/Active antenna

Note: If the antenna is active type, the power should be given by main board because there is no power supply on the GPS antenna pad. If the antenna is passive, it is suggested that the external LNA should be used.

4.3.2 GNSS Application Guide

Users can adopt a passive antenna to HERACLES 224G, and don’t need to add an external LNA, since the LNA is inside the module. The following figures are the reference circuits.

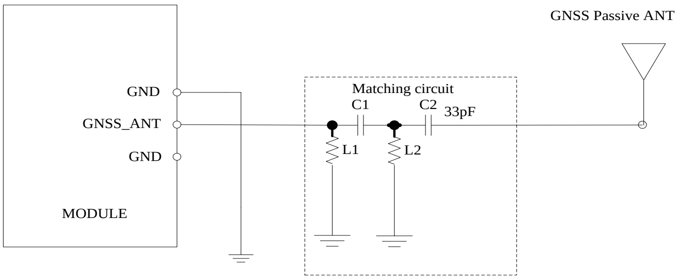


Figure 25: Passive antenna circuit

In above figures, the components C1, L1 and L2 are used for antenna matching. Usually, the values of the components can only be achieved after antenna tuning and usually provided by antenna vendor. C2 is used for DC blocking.

GNSS can be tested by NMEA port. NMEA sentences can be obtained through UART or USB automatically. NMEA sentences include GSV, GGA, RMC, GSA, and VTG. Before using GNSS, user should configure HERACLES 224G in proper operating mode by AT command. Please refer to related documents for details. HERACLES 224G can also get position location information through AT directly.

Note:

1. ***GNSS is closed by default and can be started by "AT+CGNSPWR=1". The AT command has two parameters, the first is on/off, and the second is GNSS mode. Default mode is standalone mode.***

AGPS mode needs more support from the mobile telecommunication network. Please refer to document [21] for more details.

2. ***Make sure there are no noise signals around GNSS antenna.***

4.4 RF traces note

4.4.1 RF traces layout

- Keep the RF trace from module ant pin to antenna as short as possible
- RF trace should be 50 Ω either on the top layer or in the inner layer
- RF trace should be avoided right angle and sharp angle.
- Put enough GND vias around RF traces.
- RF trace should be far away from other high speed signal lines.

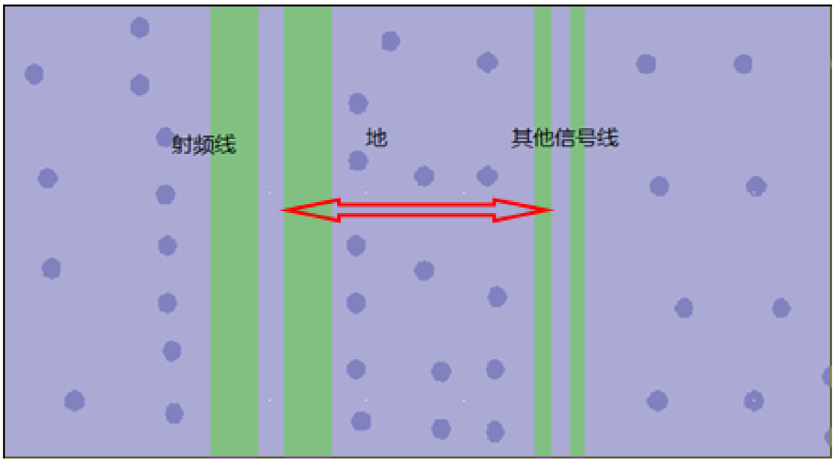


Figure 26: RF trace should be far away from other high speed signal lines

- Avoiding the paroling rout of other system antennas nearly.
- There should be some distance from The GND to the inner conductor of the SMA connector. It is better to keep out all the layers from inner to the outer conductor.

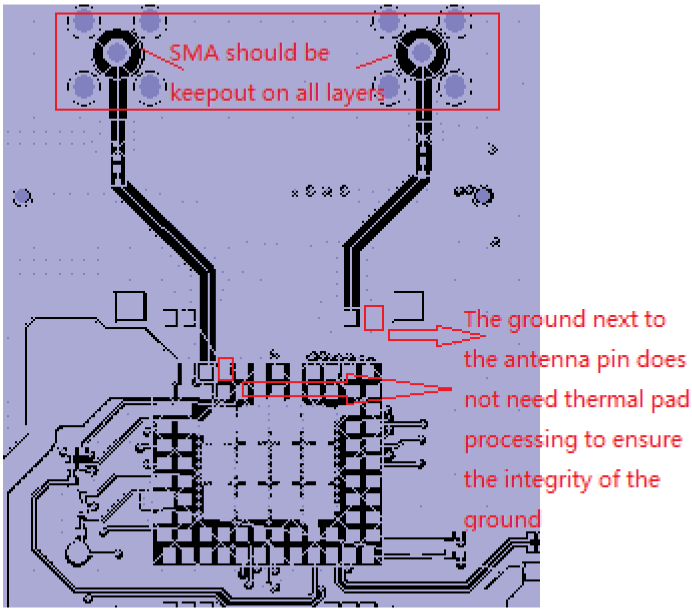

SMA should be keepout on all layers
The ground next to the antenna pin does not need thermal pad processing to ensure the integrity of the ground

Figure 27: The distance between GND to the inner conductor of SMA

- GND pads around the ANT pad should not be hot pad to keep the GND complete.

4.4.2 LTE ANT and other system ANT decoupling

- Make sure the efficiency of LTE main ANT more than 40%
- Keep the decoupling of LTE main ANT to WLAN ANT more than 15dB
- Keep the decoupling of LTE main ANT to GNSS ANT more than 30dB

Note: The decoupling value can be provided by ANT adventure. More details can refer to the document [22].

5 Electrical Specifications

5.1 Absolute maximum ratings

Absolute maximum rating for digital and analog pins of HERACLES 224G are listed in the following table:

Table 27: Absolute maximum ratings

Parameter	Min.	Typ.	Max.	Unit
Voltage on VBAT	-0.3	-	5.0	V
Voltage on USB_VBUS	-0.3	-	5.8	V
Voltage at digital pins (RESET,GPIO,I2C,UART,PCM)	-0.3	-	2.1	V
Voltage at PWRKEY	-0.3	-	3.4	V
ADC	-0.3	-	VBAT	V

The absolute parameter is tested when VBAT has the power but the PWRKEY has no pulled down. If it is over the range, the module will be damage. If the power supply on VBAT pin had been shut down, and the other pin should not have the voltage. Otherwise, it may lead to abnormally boot up or damage the module.

5.2 Operating conditions

Table 28: Recommended operating ratings

Parameter	Min.	Typ.	Max.	Unit
Voltage at VBAT	3.0	3.8	4.3	V
Voltage at USB_VBUS	3.5	5.0	5.25	V

Make sure that the voltage on the VBAT pins will never drop below 3.0V, even during a transmit burst when current consumption may rise up to 2A. If the voltage drops below 3.0V, module will be power down.

Table 29: 1.8V Digital I/O characteristics*

Parameter	Description	Min.	Typ.	Max.	Unit
V_{IH}	High-level input voltage	1.17	1.8	2.1	V
V_{IL}	Low-level input voltage	-0.3	0	0.63	V
V_{OH}	High-level output voltage	1.35	-	1.8	V
V_{OL}	Low-level output voltage	0	-	0.45	V
I_{OH}	High-level output current(no pull down resistor)	-	2	-	mA
I_{OL}	Low-level output current(no pull up resistor)	-	-2	-	mA
I_{IH}	Input high leakage current (no pull down resistor)	-	-	1	uA
I_{IL}	Input low leakage current(no pull up resistor)	-1	-	-	uA

Note: These parameters are for digital interface pins, such as GPIOs (including NETLIGHT, STATUS, SIM_DET), I2C, UART, PCM, MDM_LOG_TX and BOOT_CFG.

The operating temperature of HERACLES 224G is listed in the following table.

Table 30: Operating temperature

Parameter	Min.	Typ.	Max.	Unit
Normal operation temperature	-30	25	80	℃
Extended operation temperature*	-40	25	85	℃
Storage temperature	-45	25	+90	℃

Note: Module is able to make and receive voice calls, data calls, SMS and make GPRS/LTE traffic in -40℃ ~ +85℃. The performance will be reduced slightly from the 3GPP specifications if the temperature is outside the normal operating temperature range and still within the extreme operating temperature range.

5.3 Operating Mode

5.3.1 Operating Mode Definition

The table below summarizes the various operating modes of HERACLES 224G product.

Table 31: Operating mode Definition

Mode		Function
Normal operation	GPRS/EDGE /LTE Sleep	In this case, the current consumption of module will be reduced to the minimal level and the module can still receive paging message and SMS.
	GPRS/EDGE /LTE Idle	Software is active. Module is registered to the network, and the module is ready to communicate.
	LTE Cat-M1 Talk	Connection between two subscribers is in progress. In this case, the power consumption depends on network settings such as DTX off/on, FR/EFR/HR, hopping sequences, and antenna.
	GPRS/EDGE/LTE Standby	Module is ready for data transmission, but no data is currently sent or received. In this case, power consumption depends on network settings.
	GPRS/EDGE/LTE Data transmission	There is data transmission in progress. In this case, power consumption is related to network settings (e.g. power control level); uplink/downlink data rates, etc.
Minimum functionality mode		AT command “AT+CFUN=0” and “AT+CSCLK=1” can be used to set the module to a minimum functionality mode without removing the power supply. In this mode, the RF part of the module will not work and the SIM card will not be accessible, but the serial port and USB port are still accessible. The power consumption in this mode is lower than normal mode.
Flight mode		AT command “AT+CFUN=4” can be used to set the module to flight mode without removing the power supply. In this mode, the RF part of the module will not work, but the serial port and USB port are still accessible. The power consumption in this mode is lower than normal mode.
Power Saving Mode (PSM)		Setting AT command” AT+CPSMS=1” can be enable the PSM mode. In this mode, The mode is similar to power-off. But the module remains registered on the network and there is no need to re-attach or re-establish the network connections. And all of the functions will be unavailable except the RTC function. PWRKEY and timer expires can wake up the module.
Extended Mode DRX (e-DRX)		In idle or sleep mode, module and the network may negotiate over non-access stratum signaling the use of extended mode DRX for reducing power consumption.

5.3.2 Sleep mode

Module can enter into sleep mode for reducing its power consumption in idle module. In sleep mode, the current consumption of module will be reduced to very small level, and module can still receive paging message and SMS.

Several hardware and software conditions must be satisfied together in order to let HERACLES 224G enter sleep mode:

- USB condition: Connected USB can’t enter into sleep mode. So if module wants to enter into sleep mode, it must disconnect the power supply for USB_VBUS first.
- Software condition: If module wants to enter into sleep mode, AT comment “AT+CSCLK=1” must be set to close some clock in the module. If the value “AT+CSCLK” is “0”, module will never enter into sleep mode.
- UART condition: If module wants to enter into sleep mode, AT comment “AT+CSCLK=1” must be set to close some clock in the module. If the value “AT+CSCLK” is “0”, module will never enter into sleep mode.

If it meets all the conditions at the same time, module will enter into sleep mode. In sleep mode, the UART is unavailable. If the host need to communicate with module, it need to pull down DTR can wake up module.

5.3.3 Minimum functionality mode and Flight mode

Minimum functionality mode ceases a majority function of the module, thus minimizing the power consumption. This mode is set by the AT command which provides a choice of the functionality levels.

- AT+CFUN=0: Minimum functionality
- AT+CFUN=1: Full functionality (Default)
- AT+CFUN=4: Flight mode

If HERACLES 224G has been set to minimum functionality mode, the RF function and SIM card function will be closed. In this case, the serial port and USB are still accessible, but RF function and SIM card will be unavailable.

If HERACLES 224G has been set to flight mode, the RF function will be closed. In this case, the serial port and USB are still accessible, but RF function will be unavailable.

When HERACLES 224G is in minimum functionality or flight mode, it can return to full functionality by the AT command “AT+CFUN=1”.

5.3.4 Power Saving Mode (PSM)

HERACLES 224G module can enter into PSM for reducing its power consumption. The mode is similar to power-off, but the module remains registered on the network and there is no need to re-attach or re-establish the network connections. So in PSM all the functions will be unavailable except the RTC function, module cannot immediately respond users' requests.

When the module wants to use the PSM, it can be enabled via "AT+CPSMS=1" command. The command takes effect after module reboot. If the network supports PSM and accepts that the module uses PSM, the network confirms usage of PSM by allocating an Active Time value to the module. Module will be into PSM according to the command from network.

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

- Pulling PWRKEY pin to low level will wake up the module.
- When the timer expires, the module will be automatically woken up.

5.3.5 Extended Mode DRX (e-DRX)

In idle or sleep mode, module and the network may negotiate over non-access stratum signaling the use of extended mode DRX for reducing power consumption.

E-DRX diagrammatic sketch refer to the following figure.

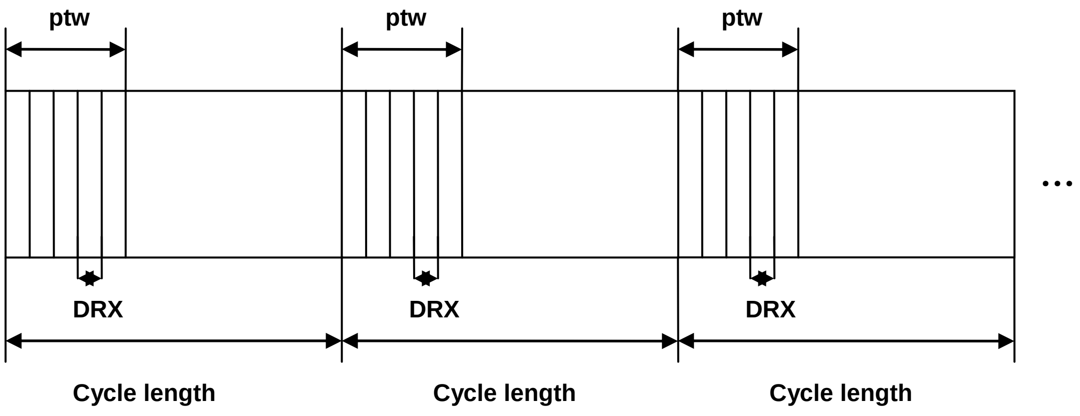


Figure 28: e-DRX diagrammatic sketch

When module and the network negotiate stratum signaling in idle mode or sleep mode, extended mode DRX can decrease the times of paging time window (PTW) and increase the cycle length. For this reason it had reduced the times of DRX, and had reduced the frequency of DRX between module and the network. So that can reduce power consumption for module.

If e-DRX is supported by the network, then it can be enabled by “AT+CEDRXS” command.

Note: For details about “AT+CEDRXS”, please refer to Document [1].

5.4 Current Consumption

The current consumption is listed in the table below.

Table 32: Current consumption on VBAT Pins (VBAT=3.8V)

GNSS	
GNSS supply current (AT+CFUN=0,without USB connection)	Tracking, typical: 30mA In DPO mode, typical: 6mA
GSM sleep/idle mode	
GSM supply current (GNSS off，without USB connection)	Sleep mode@ BS_PA_MFRMS=2 Typical: 1.7mA Idle mode@ BS_PA_MFRMS=2 Typical: 11.4mA
LTE sleep/idle mode	
LTE supply current (GNSS off，without USB connection)	Sleep mode Typical: 1.2mA Idle mode Typical: 11mA
Power Saving Mode	
PSM supply current	PSM mode Typical: 9uA
e-DRX	
e-DRX mode supply current （Tested in sleep mode）	@Cycle Length=10.24s, PTW=10.24s, Typical：2.5mA
	@Cycle Length=40.96s, PTW=20.48s, Typical：1.5mA
	@Cycle Length=10min55.36s, PTW=20.48s, Typical：1mA
	@Cycle Length=43min41.44s, PTW=20.48s, Typical：0.65mA
GPRS	
GSM850(2 Rx,4 Tx)	@power level #5 Typical: 422mA
EGSM900(2 Rx,4 Tx)	@power level #5 Typical: 422mA
DCS1800(2 Rx,4 Tx)	@power level #0 Typical: 345mA
PCS1900(2 Rx,4 Tx)	@power level #0 Typical: 345mA
GSM850(3Rx, 2 Tx)	@power level #5 Typical: 321mA
EGSM900(3Rx, 2 Tx)	@power level #5 Typical: 321mA
DCS1800(3Rx, 2 Tx)	@power level #0 Typical: 249mA
PCS1900(3Rx, 2 Tx)	@power level #0 Typical: 249mA
EDGE	
GSM850(2 Rx,4 Tx)	@power level #8 Typical: 426mA
EGSM900(2 Rx,4 Tx)	@power level #8 Typical: 426mA
DCS1800(2 Rx,4 Tx)	@power level #2 Typical: 327mA
PCS1900(2 Rx,4 Tx)	@power level #2 Typical: 327mA
GSM850(3Rx, 2 Tx)	@power level #8 Typical: 263mA
EGSM900(3Rx, 2 Tx)	@power level #8 Typical: 263mA
DCS1800(3Rx, 2 Tx)	@power level #2 Typical: 200mA
PCS1900(3Rx, 2 Tx)	@power level #2 Typical: 200mA
LTE Cat-M	
LTE-FDD B1	@23dbm Typical: 161mA @10dbm Typical: 111mA

	@0dbm Typical: 98mA
LTE-FDD B2	@23dbm Typical: 160mA @10dbm Typical: 116mA @0dbm Typical: 102mA
LTE-FDD B3	@23dbm Typical: 150mA @10dbm Typical: 110mA @0dbm Typical: 102 mA
LTE-FDD B4	@23dbm Typical: 150mA @10dbm Typica : 114mA @0dbm Typical: 102mA
LTE-FDD B5	@23dbm Typical: 168mA @10dbm Typical: 117mA @0dbm Typical: 113mA
LTE-FDD B8	@23dbm Typical: 165mA @10dbm Typical: 110mA @0dbm Typical: 98mA
LTE-FDD B12	@23dbm Typical: 167mA @10dbm Typical: 109mA @0dbm Typical: 96mA
LTE-FDD B13	@23dbm Typical: 168mA @10dbm Typical: 114mA @0dbm Typical: 97mA
LTE-FDD B17	@23dbm Typical: 168mA @10dbm Typical: 114mA @0dbm Typical: 97mA
LTE-FDD B18	@23dbm Typical: 167mA @10dbm Typical: 109mA @0dbm Typical: 98mA
LTE-FDD B19	@23dbm Typical: 171mA @10dbm Typical: 110mA @0dbm Typical: 99mA
LTE-FDD B20	@23dbm Typical: 167mA @10dbm Typical: 110mA @0dbm Typical: 98mA
LTE-FDD B26	@23dbm Typical: 168mA @10dbm Typical: 109mA @0dbm Typical: 98mA
LTE-FDD B28	@23dbm Typical: 195mA @10dbm Typical: 135mA @0dbm Typical: 115mA
LTE-TDD B39	TBD

LTE Cat-NB data transmission		
B5	UL mac padding _15KHZ_1RU_1 subcarrier_0dbm	59.94 mA
	UL mac padding _15KHZ_1RU_1 subcarrier_10dbm	68.48 mA
	UL mac padding _15KHZ_1RU_1 subcarrier_23dbm	143.22 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_0dbm	83.60 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_10dbm	100.03 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_23dbm	244.96 mA
	UL mac padding _15KHZ_12subcarrier_23dbm	92mA
	DL mac padding _15KHZ_12subcarrier_23dbm	66.42mA
B8	UL mac padding _15KHZ_1RU_1 subcarrier_0dbm	60.42 mA

	UL mac padding _15KHZ_1RU_1 subcarrier_10dbm	69.54 mA
	UL mac padding _15KHZ_1RU_1 subcarrier_23dbm	144.60 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_0dbm	83.84 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_10dbm	101.37 mA
	UL mac padding _3.75KHZ_1RU_1 subcarrier_23dbm	248.67 mA
	UL mac padding _15KHZ_12subcarrier_23dbm	93mA
	DL mac padding _15KHZ_12subcarrier_23dbm	68.4mA

5.5 ESD Notes

HERACLES 224G is sensitive to ESD in the process of storage, transporting, and assembling. When HERACLES 224G is mounted on the users’ mother board, the ESD components should be placed beside the connectors which human body may touch, such as SIM card holder, audio jacks, switches, keys, etc. The following table shows the HERACLES 224G ESD measurement performance without any external ESD component.

Table 33: The ESD performance measurement table (Temperature: 25℃, Humidity: 45%.)

Part	Contact discharge	Air discharge
VBAT,GND	+/-6K	+/-12K
Antenna port	+/-5K	+/-10K
Other PADs	+/-1K	+/-3K

6 SMT Production Guide

6.1 Top and Bottom View of HERACLES 224G

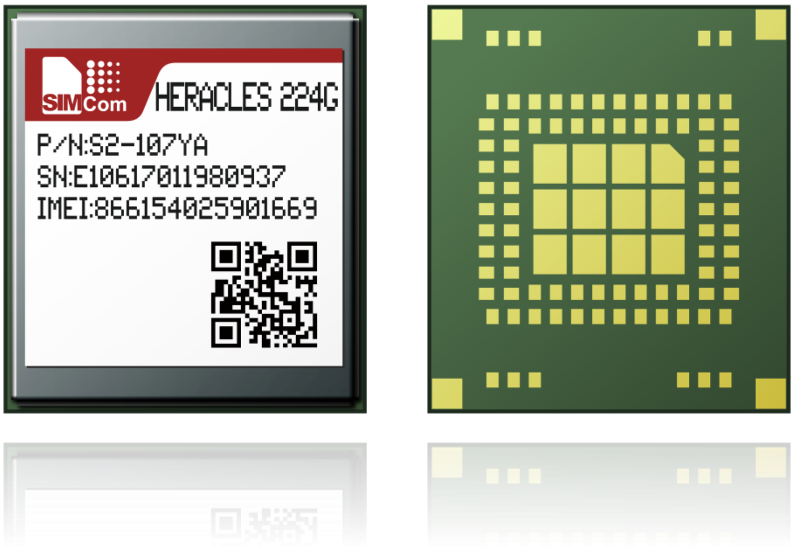

SIMCom
HERACLES 224G
P/N:S2-107YA
SN:E10617011980937
IMEI:866154025901669

Figure 29: Top and bottom view of HERACLES 224G

6.2 Label Information

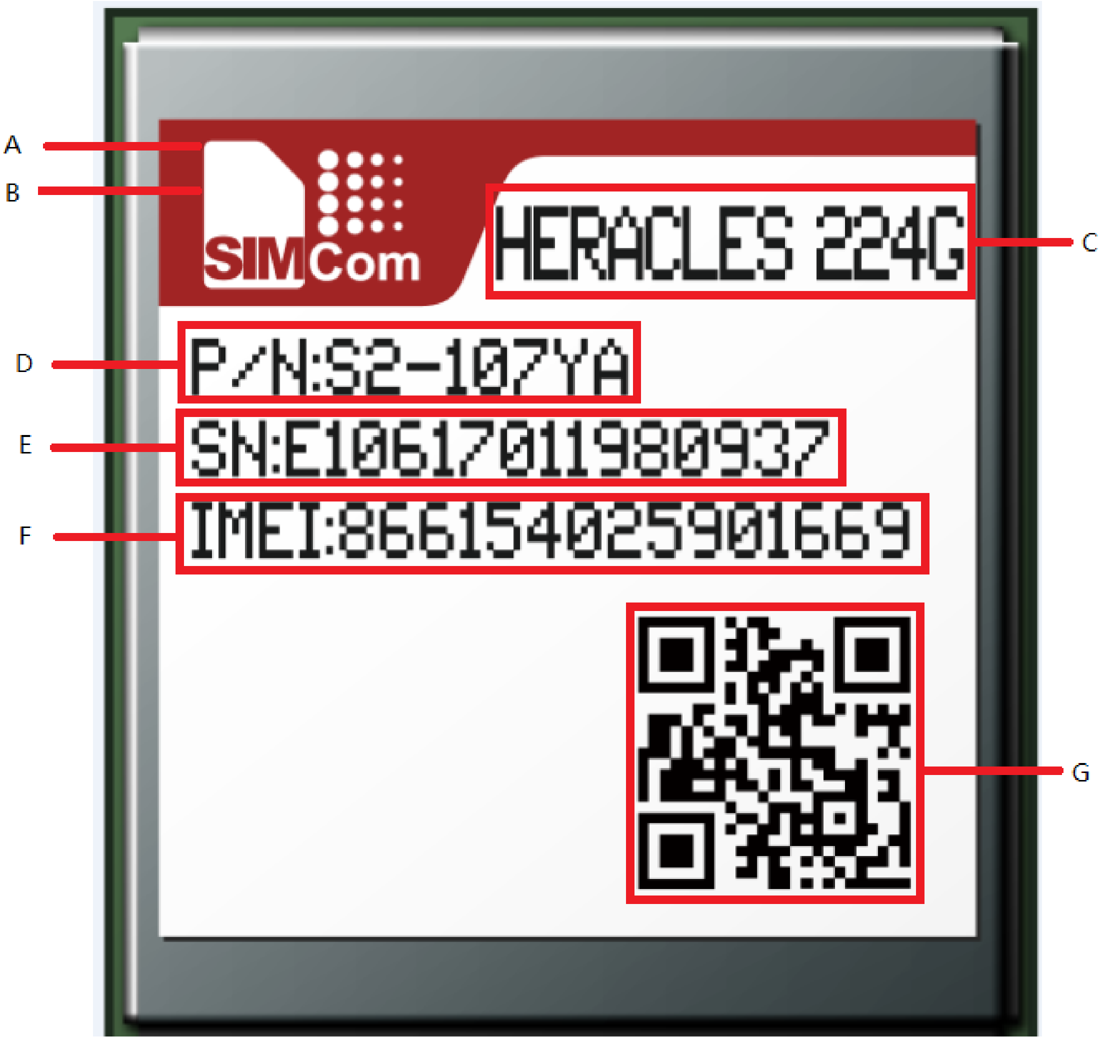

A
B
HERACLES 224G
C
D
P/N:S2-107YA
E
SN:E1061701198O937
F
IMEI:866154025901669
G

Figure 30: Label information

Table 34: The description of label information

No.	Description
A	LOGO
B	No.1 Pin
C	Project name
D	Product code
E	Serial number
F	International mobile equipment identity
G	QR code

6.3 Typical SMT Reflow Profile

SIMCom provides a typical soldering profile. Therefore the soldering profile shown below is only a generic recommendation and should be adjusted to the specific application and manufacturing constraints.

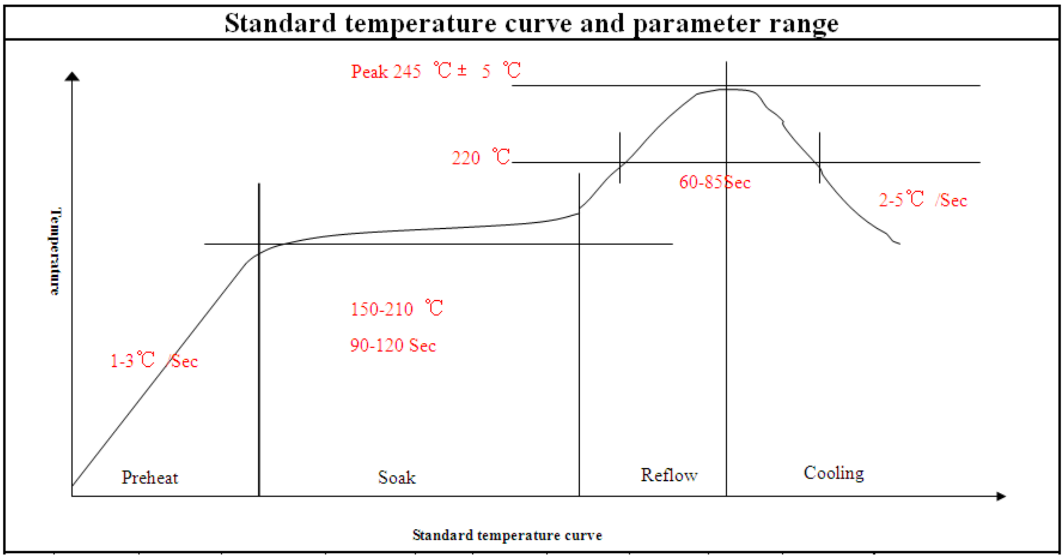


Figure 31: The ramp-soak-spike reflow profile of HERACLES 224G

Note: For more details about secondary SMT, please refer to the document [19].

6.4 Moisture Sensitivity Level (MSL)

HERACLES 224G is qualified to Moisture Sensitivity Level (MSL) 4 in accordance with JEDEC J-STD-033.

The following table shows the features of Moisture Sensitivity Level (MSL). After seal off, storage conditions must meet the following table. If the storage time was expired, module must be baking before SMT.

Table 35: Moisture Sensitivity Level and Floor Life

Moisture Sensitivity Level (MSL)	Floor Life (out of bag) at factory ambient≤30°C/60% RH or as stated
1	Unlimited at ≦30℃/85% RH
2	1 year at ≦30℃/60% RH
2a	4 weeks at ≦30℃/60% RH
3	168 hours at ≦30℃/60% RH
4	72 hours at ≦30℃/60% RH
5	48 hours at ≦30℃/60% RH
5a	24 hours at ≦30℃/60% RH
6	Mandatory bake before use. After bake, it must be reflowed within the time limit specified on the label.

6.5 Baking

In order to get better yield, the module need to bake before SMT.

- If the packaging is in perfect condition, the module which date of production is within six months has no use for baking. If the date of production is more than six months, the module must be baking.
- If the packaging had been opened or damaged, the module must be baking.

Table 36: Baking conditions

conditions	parameters
Baking temperature	120℃
Baking time	8 hours

NOTE: IPC / JEDEC J-STD-033 standard must be followed for production and storage.

6.6 Stencil Foil Design Recommendation

The recommended thickness of stencil foil is 0.15mm.

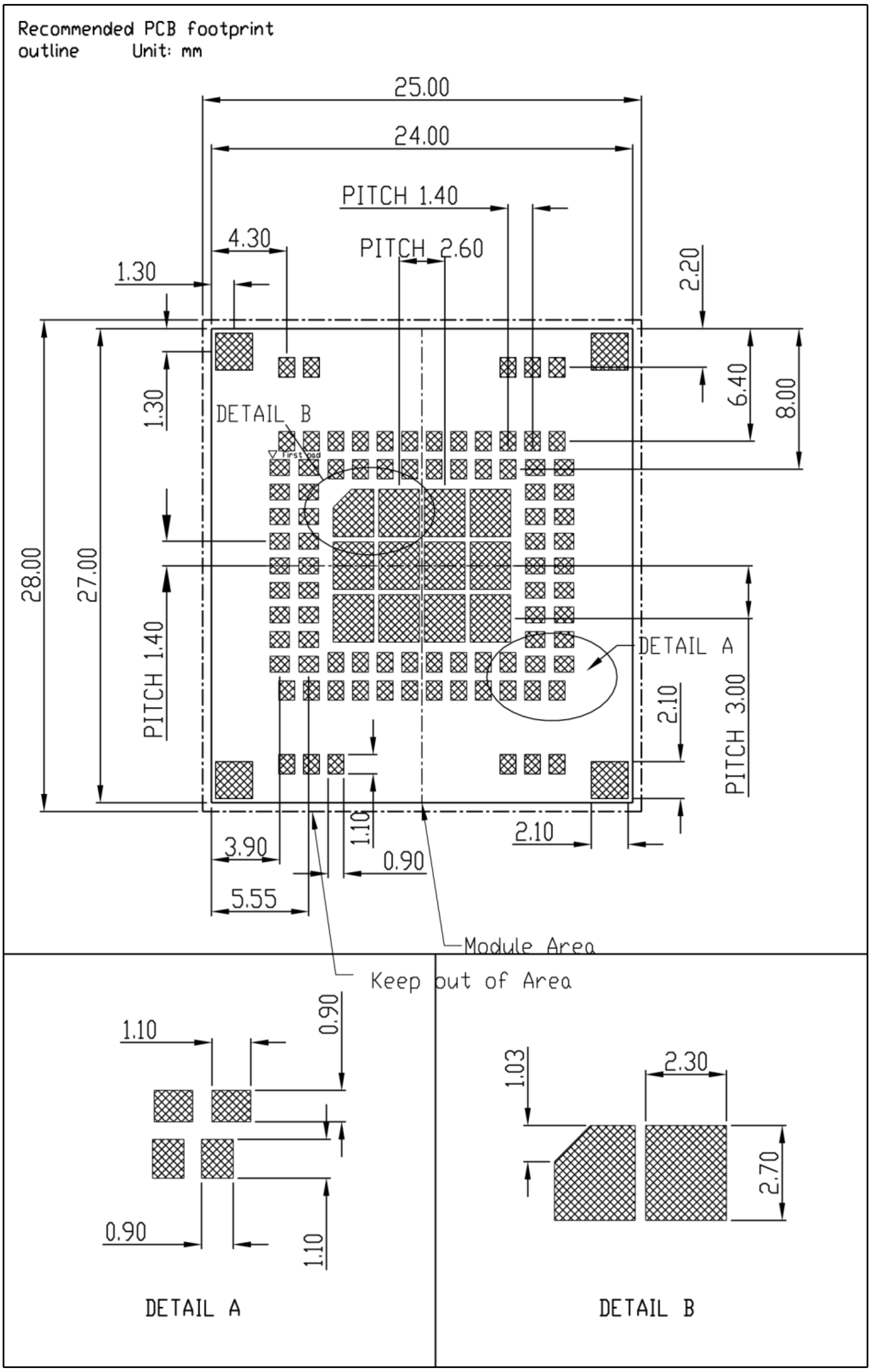

Recommended PCB footprint
outline Unit: mm
25.00
24.00
PITCH 1.40
PITCH 2.60
4.30
1.30
2.20
6.40
8.00
1.30
DETAIL B
First pad
28.00
27.00
PITCH 1.40
DETAIL A
2.10
PITCH 3.00
1.10
3.90
0.90
2.10
5.55
Module Area
Keep out of Area
1.10
0.90
0.90
1.10
DETAIL A
1.03
2.30
2.70
DETAIL B

Figure 32: stencil recommendation (Unit: mm)

7 Packaging

7.1 Tray packaging

HERACLES 224G module support tray packaging .

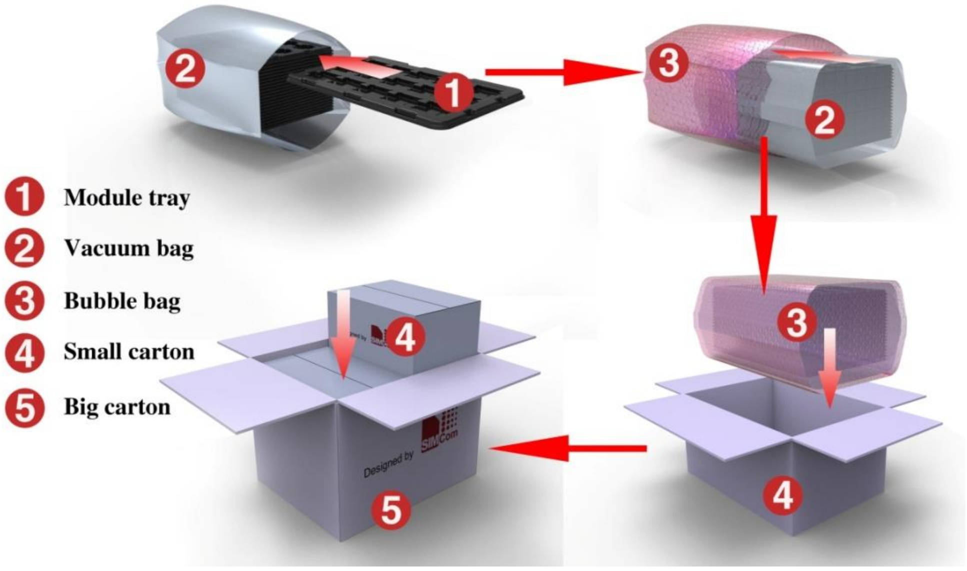

① Module tray
② Vacuum bag
③ Bubble bag
④ Small carton
⑤ Big carton
Designed by
SIMCom

Figure 33: packaging diagram

Module tray drawing：

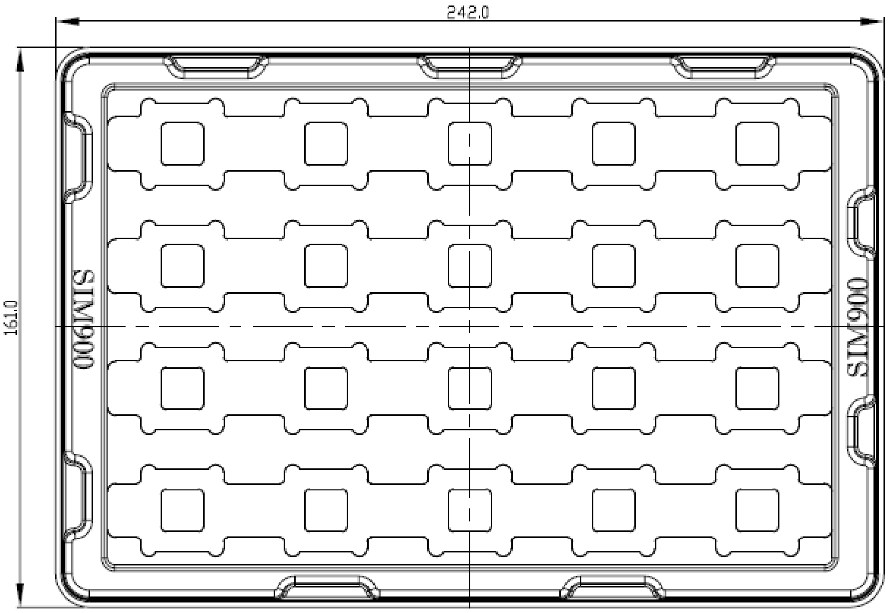

242.0
161.0
SIM900
SIM900

Figure 34: Tray drawing

Table 37: Tray size

Length（±3mm）	Width（±3mm）	Module number
242.0	161.0	20

Small carton drawing：

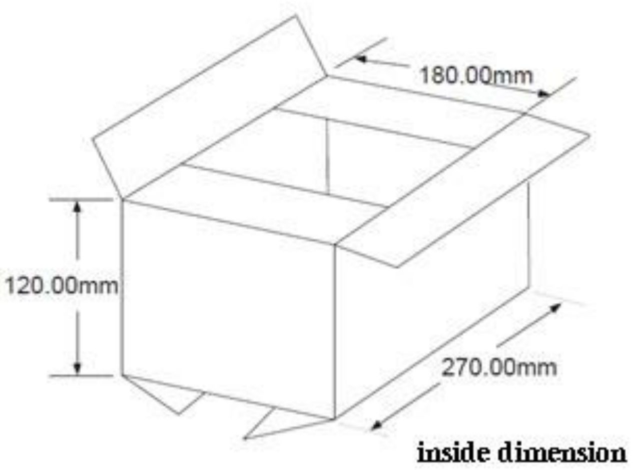

180.00mm
120.00mm
270.00mm
inside dimension

Figure 35: Small carton drawing

Table 38: Small Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
270	180	120	20*20=400

Big carton drawing：

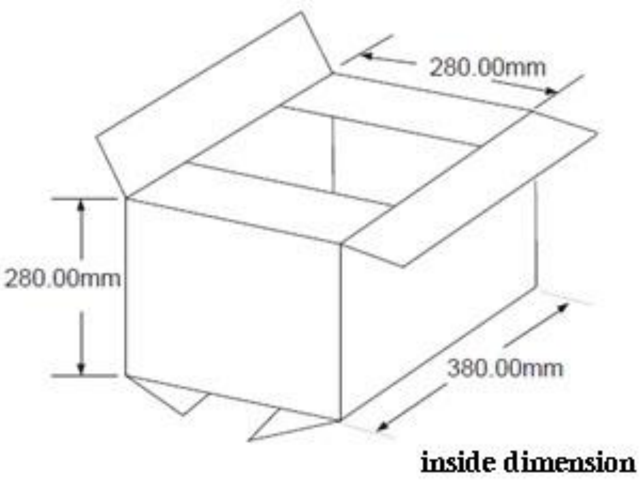

280.00mm
280.00mm
380.00mm
inside dimension

Figure 36: Big carton drawing

Table 39: Big Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
380	280	280	400*4=1600

Appendix

A. Design check list

Table 40: Schematic Check List

NO.	Items
1	Insure the supply voltage for VBAT is within the range of 3V~4.3V.
2	Insure the maximum supply current for VBAT is above its consumption when it is maximum power emission. The maximum current is 2A during GPRS/EDGE emission maximum power, and it 0.6A during LTE emission maximum power.
3	Insure the capacitor for VBAT is meet its request, in order to avoid the voltage drop exceed 300mV. And the voltage never dropped below 3V.
4	Insure the input signal for PWRKEY pin meet its electrical level match. It recommended use BJT to shift its level.
5	Insure the input signal for NRESET pin meet its electrical level match.
6	Insure the net connections of UART be correctness according to signal direction. Insure the signal for UART pins meet its electrical level match. It recommended use BJT or level shift IC to shift its level.
7	Insure USB port had used TVS to protect signal. And the junction capacity of TVS for DP/DM must be less than 1pf.
8	Insure SIM card signal had used TVS to protect. And the junction capacity of TVS must be less than 50pf.
9	Insure SIM_DET had used resistor 10Kohm pull up to VDD_EXT if used this signal.
10	Insure I2C signal had used resistors 2.2Kohm pull up to VDD_EXT if used.
11	The electrical level of all GPIOs is 1.8V. Insure the signal for GPIO pins meet its electrical level match.
12	The input range of ADC is 0V~VBAT. Insure the input signal never exceed its range.
13	User must pull up DTR when module enters into sleep mode. Insure DTR can be controlled by host.
14	Suggesting to reserve test ports for VDD_EXT and BOOT_CFG. BOOT_CFG should keep open before boot up.
15	The power supply of the active antenna should be controlled and closed.
16	LTE main ANT should have a PI type matching to debug antenna
17	LTE main ANT should Keep TVS to prevent ESD destroyed. And the TVS should be Low junction capacitance.

Table 41: PCB Layout Check List

NO.	Items
1	Insure the capacitor placement for VBAT be near module pin.
2	Insure VBAT trace width be greater than 2mm. If NB only, insure VBAT trace width be greater than 0.6mm. And the VIA number must be enough for getting through the current.
3	Insure the return path GND of the power supply is good. Insure the connectivity between module GND and mother board GND is good.
4	Insure PCM trance is protected by GND, and keep it far from interference source, such as power supply trace, USB trace, RF trace and so on.

5	Insure USB trance is protected by GND, and keep it far from interference source, such as power supply trace, RF trace and so on. Insure DM/DP trace is differential routing, and differential impedance is 90 ohm.
6	Insure ADC trance is protected by GND.
7	Insure SIM card signal trance is protected by GND. Especially SIM_CLK must be protected alone. And avoid signal trace branched Routing.
8	Insure I2C trance is protected by GND.
9	Insure TVS avoid bypass. The trace must go through TVS pad first, and then arrived module pad.
10	There should be enough ground around the RF line. RF lines Routing prohibit right angles and sharp angles, trying to trace circular or obtuse angle line.
11	The RF line reference GND should be complete. And avoid high speed lines crossing below it.
12	the GND side of the RF output pin should be non hot welding disk
13	The routing which is RF output PIN to antenna should be isolated from other high-speed lines. And the routing should be 50Ω impedance control.

B. Coding Schemes and Maximum Net Data Rates over Air Interface

Table 42: Coding Schemes and Maximum Net Data Rates over Air Interface

Multi slot definition(GPRS/EDGE)			
Slot class	**DL slot number**	**UL slot number**	**Active slot number**
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
GPRS coding scheme	**Max data rata（4 slots）**		**Modulation type**
CS 1 = 9.05 kb/s / time slot	36.2 kb/s		GMSK
CS 2 = 13.4 kb/s / time slot	53.6 kb/s		GMSK
CS 3 = 15.6 kb/s / time slot	62.4 kb/s		GMSK
CS 4 = 21.4 kb/s / time slot	85.6 kb/s		GMSK
EDGE coding scheme	**Max data rata（4 slots）**		**Modulation type**
MCS 1 = 8.8 kb/s/ time slot	35.2 kb/s		GMSK
MCS 2 = 11.2 kb/s/ time slot	44.8 kb/s		GMSK
MCS 3 = 14.8 kb/s/ time slot	59.2 kb/s		GMSK
MCS 4 = 17.6 kb/s/ time slot	70.4 kb/s		GMSK
MCS 5 = 22.4 kb/s/ time slot	89.6 kb/s		8PSK
MCS 6 = 29.6 kb/s/ time slot	118.4 kb/s		8PSK
MCS 7 = 44.8 kb/s/ time slot	179.2 kb/s		8PSK
MCS 8 = 54.4 kb/s/ time slot	217.6 kb/s		8PSK
MCS 9 = 59.2 kb/s/ time slot	236.8 kb/s		8PSK
LTE-FDD device category (Downlink)	**Max data rate（peak）**		**Modulation type**
Category 1	10Mbps		QPSK/16QAM/64QAM
Category 2	50Mbps		QPSK/16QAM/64QAM
Category 3	100Mbps		QPSK/16QAM/64QAM
Category 4	150Mbps		QPSK/16QAM/64QAM
LTE-FDD device category (Uplink)	**Max data rate（peak）**		**Modulation type**
Category 1	5Mbps		QPSK/16QAM

Category 2	25Mbps	QPSK/16QAM
Category 3	50Mbps	QPSK/16QAM
Category 4	50Mbps	QPSK/16QAM

C. Related Documents

Table 43: Related Documents

NO.	Title	Description
[1]	HERACLES 224G Series AT Command Manual V1.xx	AT Command Manual
[2]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[3]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[4]	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)
[5]	GSM 11.14	Digital cellular telecommunications system (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity Module – Mobile Equipment (SIM – ME) interface
[6]	GSM 11.11	Digital cellular telecommunications system (Phase 2+); Specification of the Subscriber Identity Module – Mobile Equipment (SIM – ME) interface
[7]	GSM 03.38	Digital cellular telecommunications system (Phase 2+); Alphabets and language-specific information
[8]	GSM 11.10	Digital cellular telecommunications system (Phase 2)； Mobile Station (MS) conformance specification； Part 1: Conformance specification
[9]	3GPP TS 51.010-1	Digital cellular telecommunications system (Release 5); Mobile Station (MS) conformance specification
[10]	3GPP TS 34.124	Electromagnetic Compatibility (EMC) for mobile terminals and ancillary equipment.
[11]	3GPP TS 34.121	Electromagnetic Compatibility (EMC) for mobile terminals and ancillary equipment.
[12]	3GPP TS 34.123-1	Technical Specification Group Radio Access Network; Terminal conformance specification; Radio transmission and reception (FDD)
[13]	3GPP TS 34.123-3	User Equipment (UE) conformance specification; Part 3: Abstract Test Suites.
[14]	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; Part 2: Harmonized EN for IMT-2000, CDMA Direct Spread (UTRA FDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive
[15]	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
[16]	IEC/EN60950-1(2001)	Safety of information technology equipment (2000)
[17]	3GPP TS 51.010-1	Digital cellular telecommunications system (Release 5); Mobile Station (MS) conformance specification
[18]	2002/95/EC	Directive of the European Parliament and of the Council of

		27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
[19]	Module secondary-SMT-UGD V1.xx	Module secondary SMT Guidelines
[20]	HERACLES 224G Series UART Application Note_V1.xx	This document describes how to use UART interface of SIMCom modules.
[21]	ETSI EN 301 908-13 (ETSI TS 136521-1 R13.4.0)	IMT cellular networks; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive; Part 13
[22]	ANTENNA DESIGN GUIDELINES FOR MULTI-ANTENNA SYSTEM V1 01	Design notice for multi-antenna.

D. Terms and Abbreviations

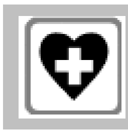
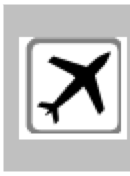
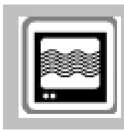
Table 44: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
ARP	Antenna Reference Point
BER	Bit Error Rate
BD	BeiDou
BTS	Base Transceiver Station
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DTE	Data Terminal Equipment (typically computer, terminal, printer)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
DAM	Downloadable Application Module
DPO	Dynamic Power Optimization
DRX	Discontinuous Reception
e-DRX	Extended Discontinuous Reception
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
EVDO	Evolution Data Only
FCC	Federal Communications Commission (U.S.)
FD	SIM fix dialing phonebook
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Standard for Mobile Communications
HR	Half Rate
HSPA	High Speed Packet Access
I2C	Inter-Integrated Circuit
IMEI	International Mobile Equipment Identity
LTE	Long Term Evolution
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
MT	Mobile Terminated
NMEA	National Marine Electronics Association
PAP	Password Authentication Protocol

PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCS	Personal Communication System, also referred to as GSM 1900
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
SIM	Subscriber Identification Module
SMS	Short Message Service
SMPS	Switched-mode power supply
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
TX	Transmit Direction
UART	Universal Asynchronous Receiver & Transmitter
VSWR	Voltage Standing Wave Ratio
SM	SIM phonebook
NC	Not connect
EDGE	Enhanced data rates for GSM evolution
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
ZIF	Zero intermediate frequency
WCDMA	Wideband Code Division Multiple Access
VCTCXO	Voltage control temperature-compensated crystal oscillator
SIM	Universal subscriber identity module
UMTS	Universal mobile telecommunications system
UART	Universal asynchronous receiver transmitter
PSM	Power saving mode
FD	SIM fix dialing phonebook
LD	SIM last dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ON	SIM (or ME) own numbers (MSISDNs) list
RC	Mobile Equipment list of received calls
SM	SIM phonebook
NC	Not connect

E. Safety Caution

Table 45: Safety Caution

Marks	Requirements
	When in a hospital or other health care facility, observe the restrictions about the use of mobiles. Switch the cellular terminal or mobile off, medical equipment may be sensitive and not operate normally due to RF energy interference.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forgetting to think much of these instructions may impact the flight safety, or offend local legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres 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 sets, radios, computers or other electric equipment.
	Road safety comes first! Do not use a hand-held cellular terminal or mobile when 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 signals and cellular networks and cannot be guaranteed to connect in all conditions, especially with a mobile fee or an invalid SIM card. While you are in this condition and need emergent help, please remember to use emergency calls. In order to make or receive calls, 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 the cellular terminal or mobile.

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