Heracles_Hardware Design_V1.02

Development Kit

Hardware Design

Reference Design

Software Design

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Contents

Table Index

Figure Index

Version History

Date	Version	Description of change	Author
2017-04-27	1.00	Origin	Ajuan.zhu, Jianmin.zhu
2017-06-27	1.01	Add external SIM card	Ajuan.zhu, Jianmin.zhu
2017-07-14	1.02	Add Packing information	Ajuan.zhu, Jianmin.zhu

1. Introduction

This document describes Heracles hardware interface in great detail. The document can help customer to quickly understand Heracles interface specifications, electrical and mechanical details. With the help of this document and other Heracles application notes, customer guide, customers can use Heracles to design various applications quickly.

2. Heracles Overview

Heracles is a quad-band GSM/GPRS module, that works on frequencies GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. Heracles features GPRS multi-slot class 12/ class 10 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.

With a tiny configuration of 17.8*15.8*2.4mm, Heracles can meet almost all the space requirements in customer applications, such as smart phone, PDA and other mobile devices.

Heracles is a LGA package with 88 pads, and provides all hardware interfaces between the module and customer's boards.

- Support 5*5*2 keypads
- One full modem serial port, customer can configure two serial ports
- One USB, the USB interfaces can debug, download software
- Audio channel which includes two microphone input; a receiver output and a speaker output
- Programmable general purpose input and output.
- Support one PWM
- One built-in M2M SIM card, support 2G/3G
- A SIM card interface

Heracles is designed with power saving technique so that the current consumption is as low as 0.545mA in sleep mode.

2.1. Heracles

Table 1: Module information

	Heracles
GSM	850,900,1800 and 1900MHz
FLASH	32Mbit
RAM	32Mbit

2.2. Heracles Key Features

Table 2: Heracles key features

Feature	Implementation
Power supply	3.4V ~4.4V
Power saving	Typical power consumption in sleep mode is0.545mA (AT+CFUN=0)
Frequency bands	• Quad-band: GSM 850, EGSM 900, DCS 1800, PCS 1900. Heracles can search

	the 4 frequency bands automatically. The frequency bands can also be set by AT command "AT+CBAND". For details, please refer to ***document [1]***. ● Compliant to GSM Phase 2/2+
Transmitting power	● Class 4 (2W) at GSM 850 and EGSM 900 ● Class 1 (1W) at DCS 1800 and PCS 1900
GPRS connectivity	● GPRS multi-slot class 12（default） ● GPRS multi-slot class 1~12 (option)
Temperature range	● Normal operation: -40°C ~ +85°C ● Storage temperature -45°C ~ +90°C
Data GPRS	● GPRS data downlink transfer: max. 85.6 kbps ● GPRS data uplink transfer: max. 85.6 kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● PAP protocol for PPP connect ● Integrate the TCP/IP protocol. ● Support Packet Broadcast Control Channel (PBCCH)
USSD	● Unstructured Supplementary Services Data (USSD) support
SMS	● MT, MO, CB, Text and PDU mode ● SMS storage: SIM card
SIM interface	● Support SIM card: 1.8V, 3V
External antenna	Antenna pad
Audio features	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 (AMR) ● Echo Cancellation ● Noise Suppression
Serial port and debug port	**Serial port:** ● Default one Full modem serial port ● 1200bps to 460800bps. ● Can be used for AT commands or data stream. ● Support RTS/CTS hardware handshake and software ON/OFF flow control. ● Multiplex ability according to GSM 07.10 Multiplexer Protocol. ● Autobauding supports baud rate from 1200 bps to 115200bps. ● upgrading firmware **Debug port:** ● USB_DN and USB_DP ● Can be used for debugging and upgrading firmware.
Phonebook management	Support phonebook types: SM, FD, LD, RC, ON, MC.
Real time clock	Support RTC
Timing functions	Use AT command set
Physical characteristics	Size: 17.8*15.8*2.4mm Weight:1.5g
Firmware upgrade	Main serial port or USB port.(recommend to use USB port)

Table 3: Coding schemes and maximum net 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

2.3. Operating Mode

The table below summarizes the various operating modes of Heracles.

Table 4: Overview of operating modes

Mode	Function	
Normal operation	GSM/GPRS SLEEP	Module will automatically go into sleep mode if the conditions of sleep mode are enabling and there is no on air and no hardware interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. In sleep mode, the module can still receive paging message and SMS.
	GSM IDLE	Software is active. Module is registered to the GSM network, and the module is ready to communicate.
	GSM 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, antenna.
	GPRS STANDBY	Module is ready for GPRS data transfer, but no data is currently sent or received. In this case, power consumption depends on network settings and GPRS configuration.
	GPRS DATA	There is GPRS data transfer (PPP or TCP or UDP) in progress. In this case, power consumption is related with network settings (e.g. power control level); uplink/downlink data rates and GPRS configuration (e.g. used multi-slot settings).
Power down		Normal power down by sending AT command "AT+CPOWD=1" or using the PWRKEY. The power management unit shuts down the power supply for the baseband part of the module, and only the power supply for the RTC is remained. Software is not active. The serial port is not accessible. Power supply (connected to VBAT) remains applied.
Minimum functionality mode		AT command "AT+CFUN" 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 serial port is still accessible. The power consumption in this mode is lower than normal mode.

Heracles_Hardware Design_V1.02   13   **2017-07-14**

2.4. Functional Diagram

The following figure shows a functional diagram of Heracles:

● GSM baseband
● GSM RF
● Antenna interface
● Other interface
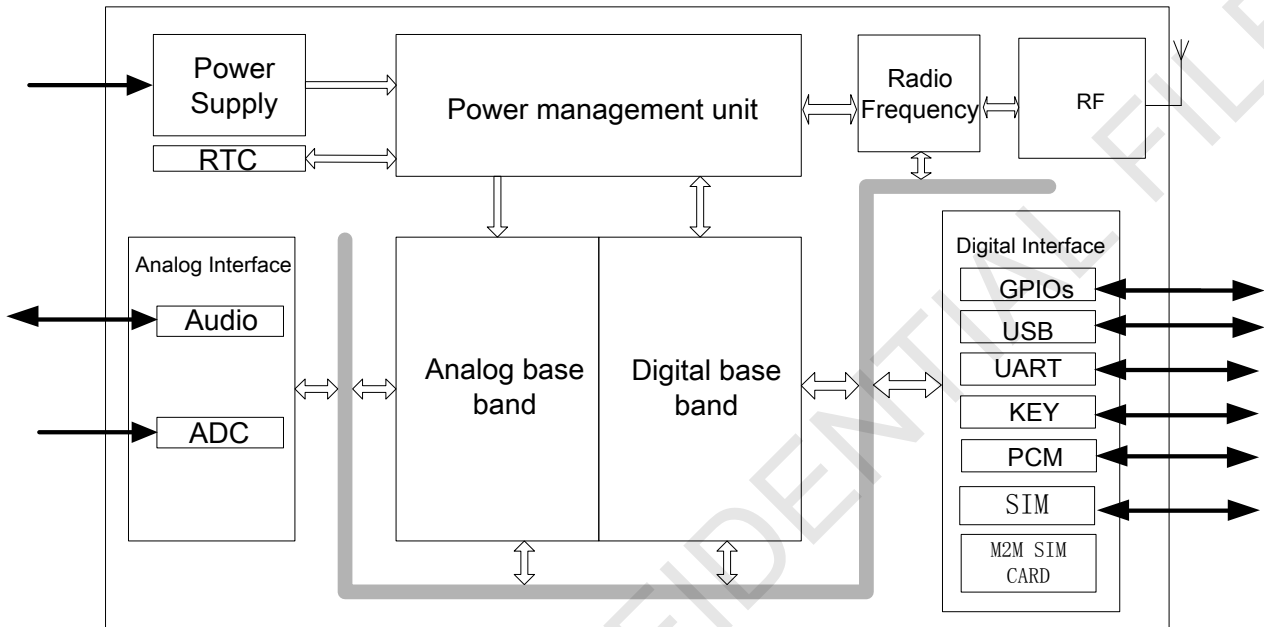
Figure 1: Heracles functional diagram

3. Package Information

3.1. Pin Out Diagram
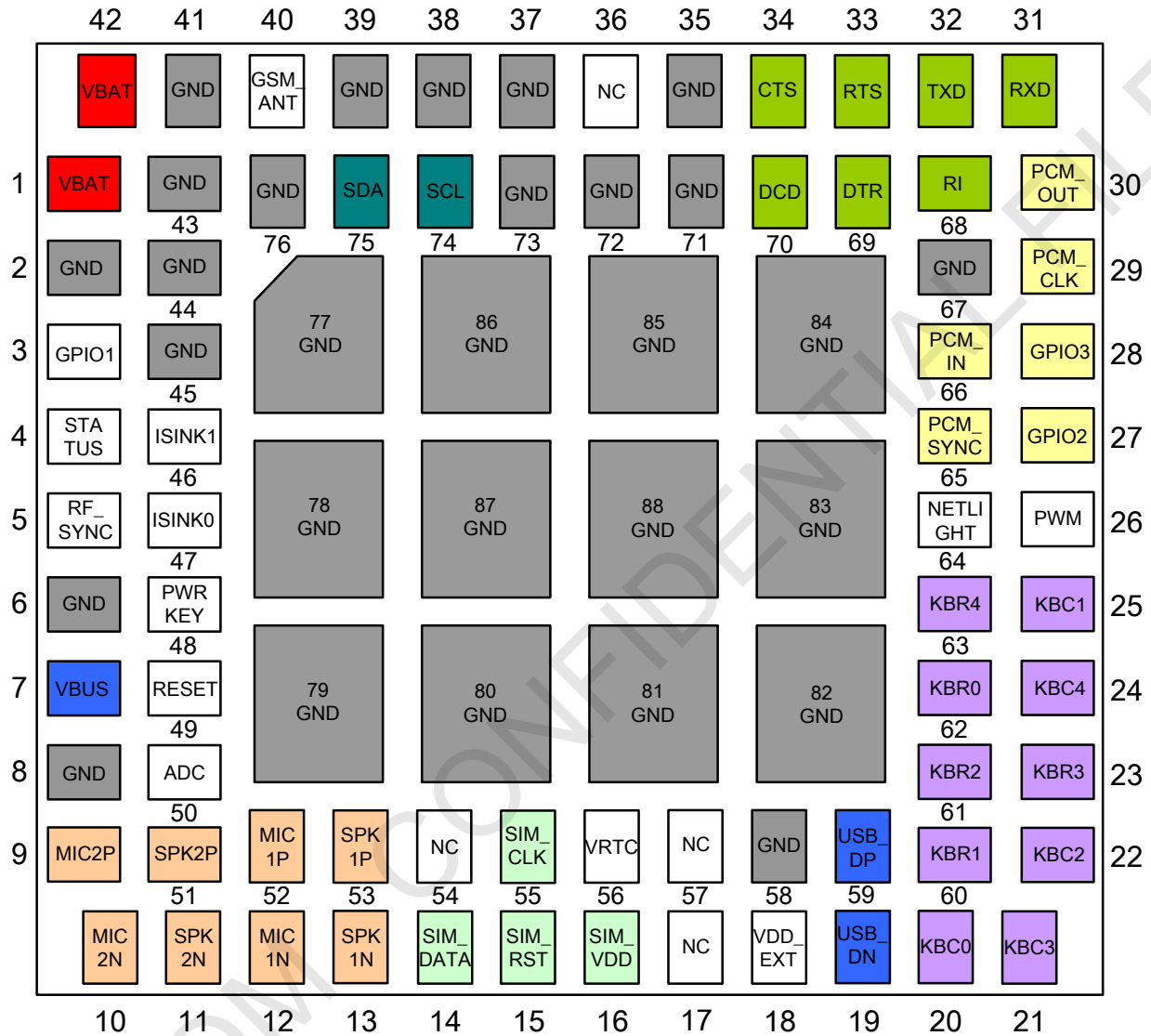
Figure 2: Pin assignment (Top view)

3.2. Pin Description

Table 5: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VBAT	1,42	I	Power supply	

VRTC	56	I/O	Power supply for RTC	It is recommended to connect with a battery or a capacitor (e.g. 4.7uF).
VDD_EXT	18	O	2.8V power output	If these pins are unused, keep open.
GND	2,6,8,35,37,38,39, 41,43,44,45,58,67 ,71,72,73,76,77,7 8,79,80,81,82,83, 84,85,86,87,88		Ground	GND for VBAT recommend to use 2,43,44,45pin
Power on/down				
PWRKEY	48	I	PWRKEY should be pulled low at least 1 second and then released to power on/down the module.	Internally pulled up to VBAT.
Audio interfaces				
MIC1P	52	I	Differential audio input	If these pins are unused, keep open.
MIC1N	12			
SPK1P	53	O	Differential audio output	
SPK1N	13			
MIC2P	9	I	Differential audio input	
MIC2N	10			
SPK2P	51	O	Differential audio output	
SPK2N	11			
PCM interface				
PCM_CLK	29	O	PCM interface for digital audio	If these pins are unused, keep open.
PCM_OUT	30	O		
PCM_SYNC	65	O		
PCM_IN	66	I		
Keypads interface				
KBC4	24	I	Support up to 50 buttons (5*5*2)	If these pins are unused, keep open.（Please make sure pin20 at high level when power on）
KBC3	21	I		
KBC2	22	I		
KBC1	25	I		
KBC0	20	I		
KBR4	63	O		
KBR3	23	O		
KBR2	61	O		
KBR1	60	O		
KBR0	62	O		
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	Debug and download	If these pins are unused, keep open.
USB_DP	59	I/O		
USB_DN	19	I/O		
ADC				
ADC	50	I	10bit general analog to digital converter	If these pins are unused, keep 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	
Antenna interface				
GSM_ANT	40	I/O	Connect GSM antenna	
Synchronizing signal of RF				
RF_SYNC	5	O	Synchronizing signal of RF	
Other				
RESET	49	I	Reset input(Active low)	
ISINK1	46	I	Drive keypad backlight	
ISINK0	47	I	Drive LCD backlight	
NC	17、36、54、57	-	Unconnected	KEEP OPEN

3.3. Package Dimensions
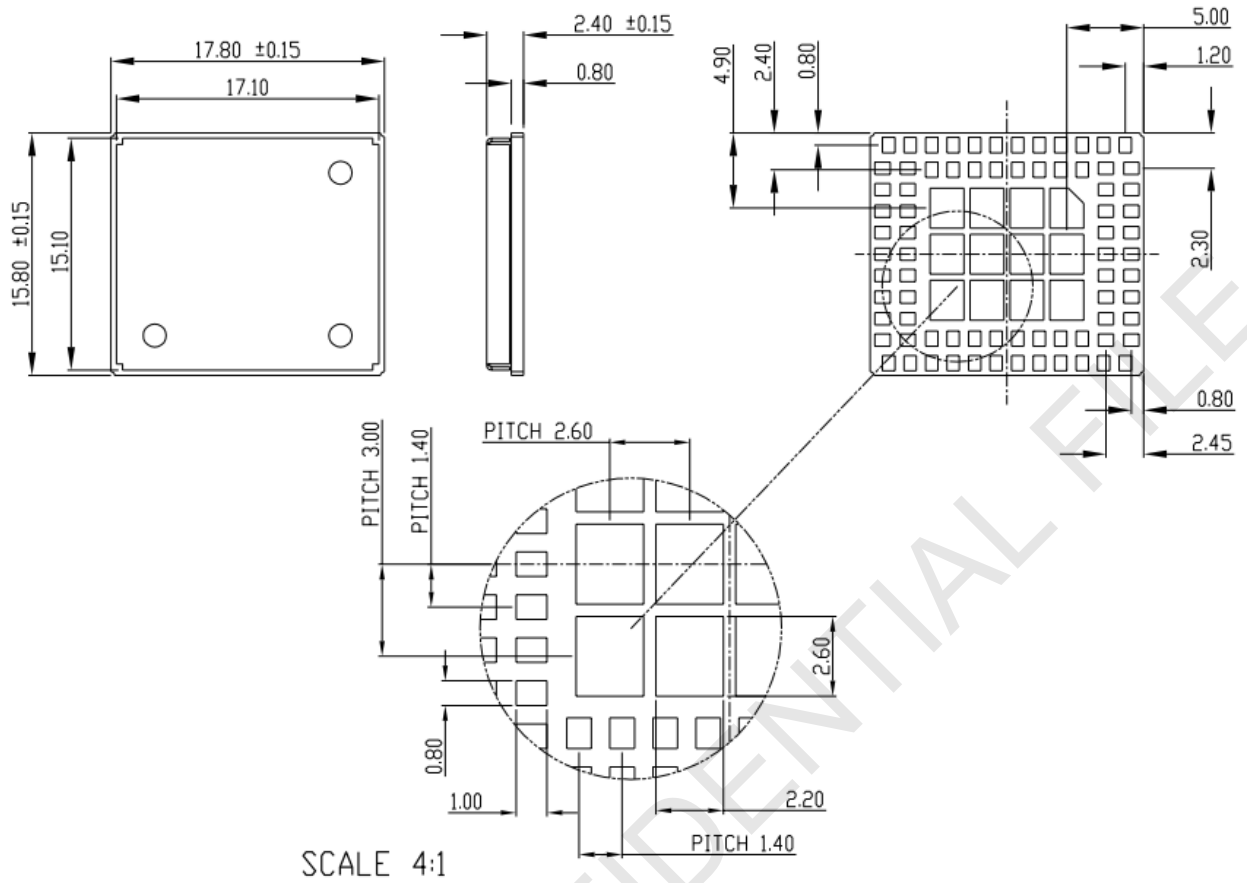
Figure 3: Dimensions of Heracles (Unit: mm)

Recommended PCB footprint
outline   Unit: mm
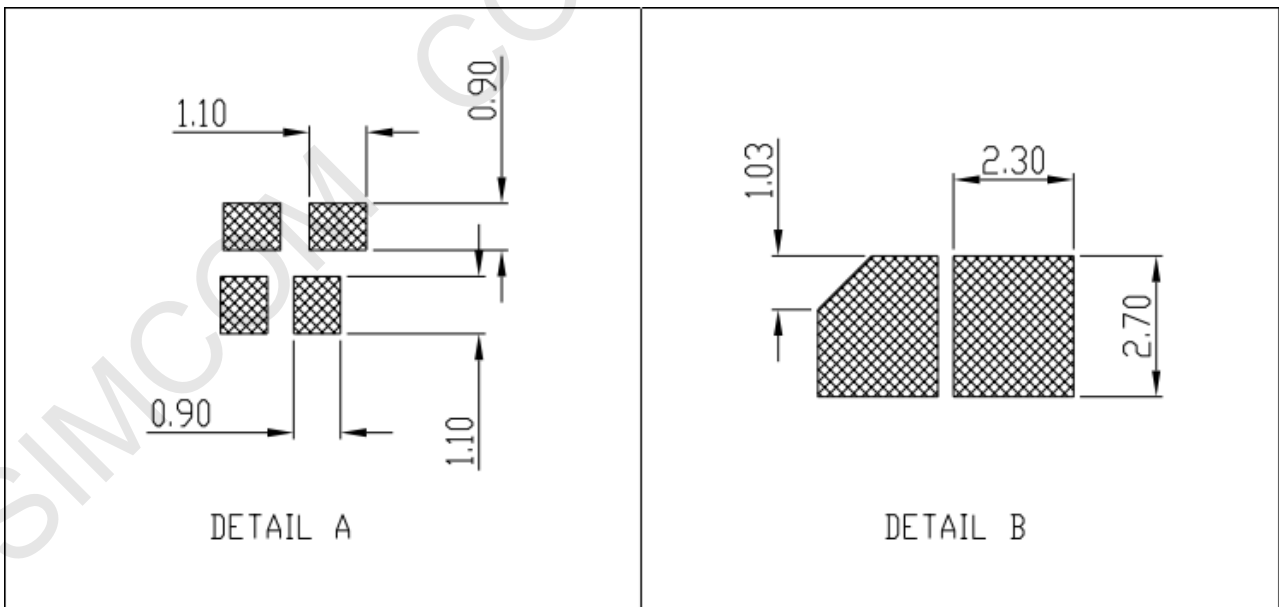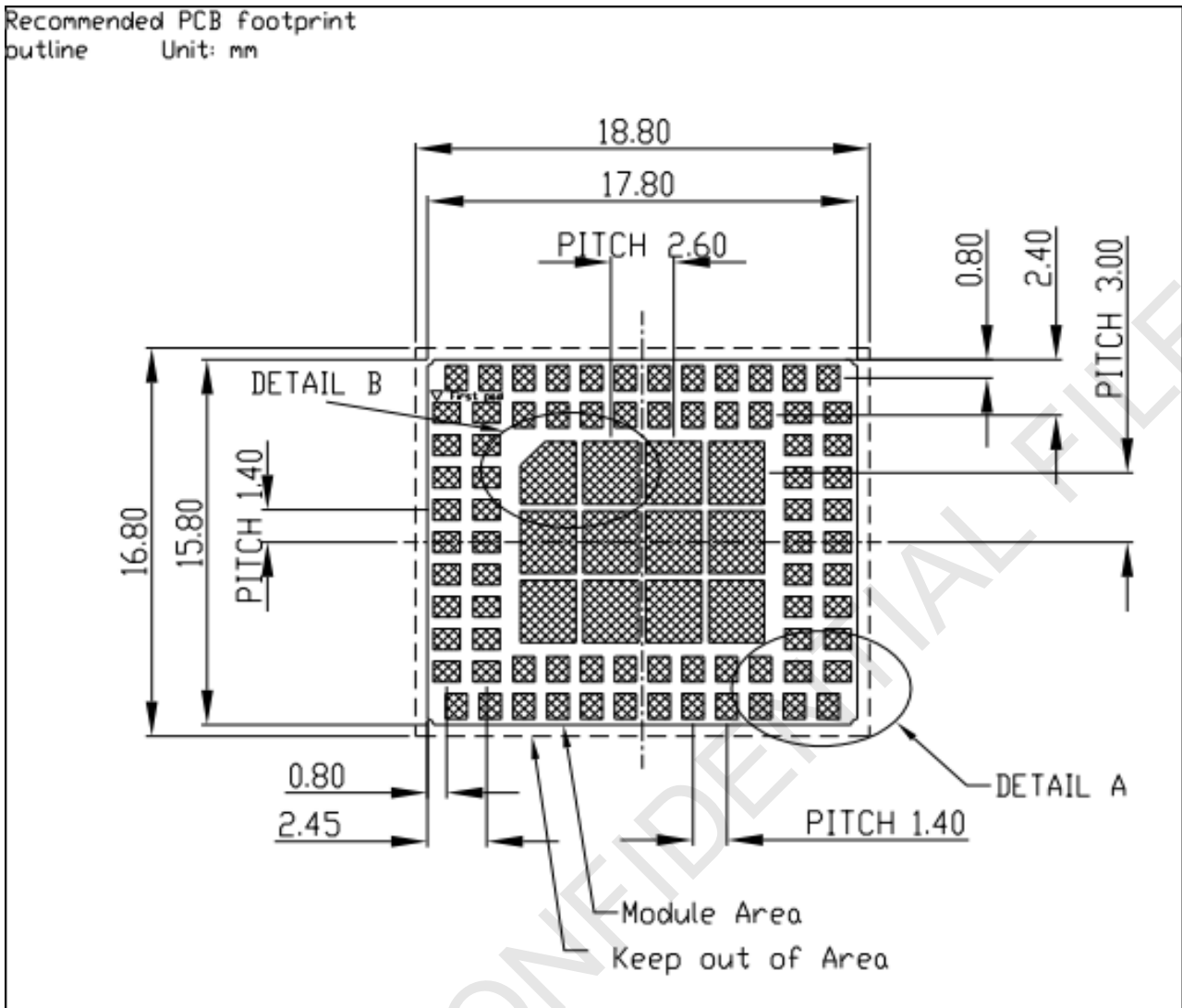
Figure 4: Recommended PCB footprint outline (Unit: mm)

4. Application Interface

4.1. Power Supply

The power supply range of Heracles is from 3.4V to 4.4V. Recommended voltage is 4.0V. The transmitting burst will cause voltage drop and the power supply must be able to provide sufficient current up to 2A. For the VBAT input, a bypass capacitor (low ESR) such as a 100uF is strongly recommended.

Increase the 33pF and 10pF capacitors can effectively eliminate the high frequency interference. A 5.1V/500mW Zener diode is strongly recommended, the diode can prevent chip from damaging by the voltage surge. These capacitors and Zener diode should be placed as close as possible to Heracles VBAT pins.
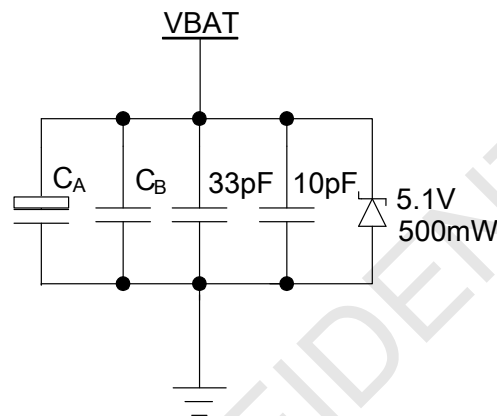
Figure 5: Reference circuit of the VBAT input

Table 6: Recommended zener diode

	Vendor	Part number	Power(watts)	Packages
1	On semi	MMSZ5231BT1G	500mW	SOD123
2	Prisemi	PZ3D4V2H	500mW	SOD323
3	Vishay	MMSZ4689-V	500mW	SOD123
4	Crownpo	CDZ55C5V1SM	500mW	0805

The following figure is the reference design of +5V input power supply. The designed output for the power supply is 4.1V, thus a linear regulator can be used.
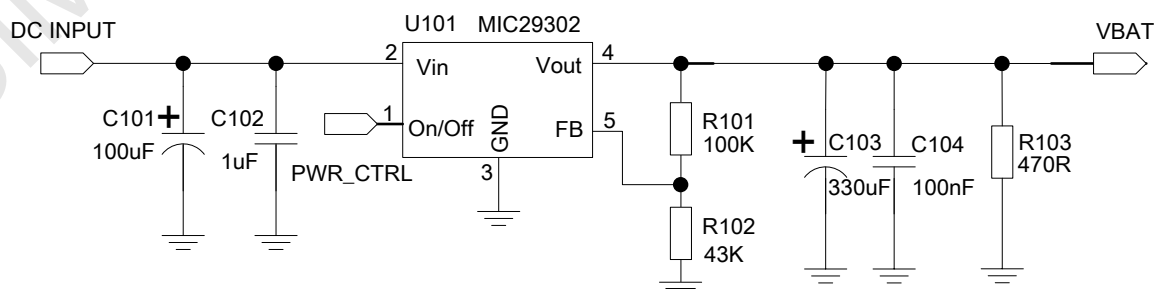
Figure 6: Reference circuit of the LDO power supply

If there is a high drop-out between the input and the desired output (VBAT), a DC-DC power supply will be preferable because of its better efficiency especially with the 2A peak current in burst mode of the module. The following figure is the reference circuit.
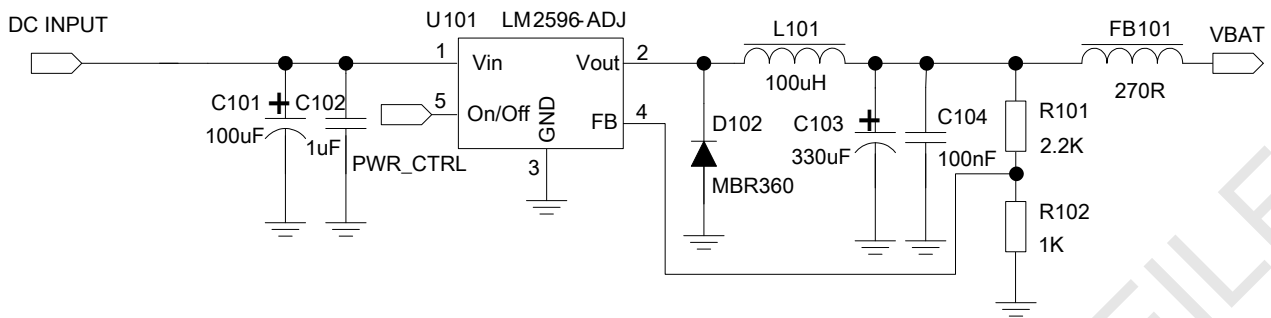
Figure 7: Reference circuit of the DC-DC power supply

The single 3.7V Li-ion cell battery can be connected to Heracles VBAT pins directly. But the Ni-Cd or Ni-MH battery must be used carefully, since their maximum voltage can rise over the absolute maximum voltage of the module and damage it.

When battery is used, the total impedance between battery and VBAT pins should be less than 150mΩ.
The following figure shows the VBAT voltage drop at the maximum power transmit phase, and the test condition is as following:

> VBAT=4.0V,
> A VBAT bypass capacitor C_A=100uF tantalum capacitor (ESR=0.7Ω),
> Another VBAT bypass capacitor C_B=1uF.
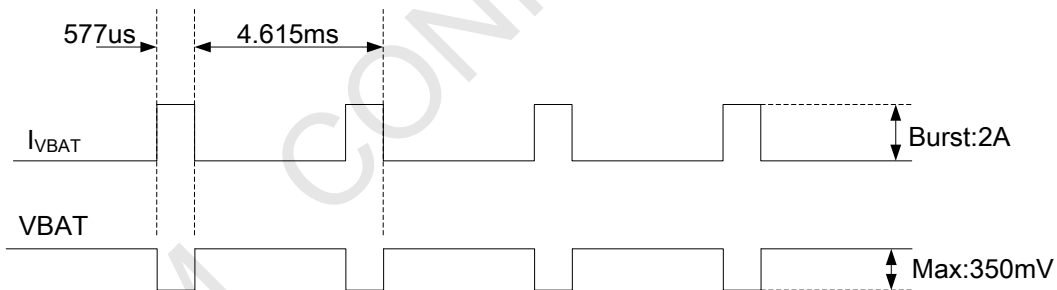
Figure 8: VBAT voltage drop during transmit burst

4.1.1. Power Supply Pin

Pin 1 and Pin 42 are VBAT input, Pins 2,43,44,45 are GND of power supply, VRTC pin is power supply of the RTC circuit in the module. VDD_EXT output 2.8V when module is in normal operation mode.

When designing the power supply in customer's application, pay special attention to power losses. Ensure that the input voltage never drops below 3.0V even when current consumption rises to 2A in the transmit burst. If the power voltage drops below 3.0V, the module may be shut down automatically. The PCB traces from the VBAT pins to the power supply must be wide enough (at least 60mil) to decrease voltage drops in the transmit burst. The power IC and the bypass capacitor should be placed to the module as close as possible.

VBAT

MIN:3.0V
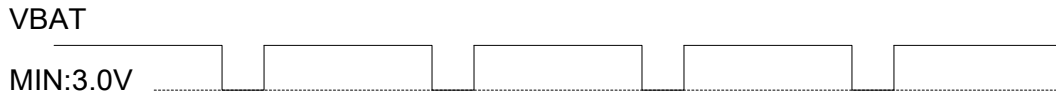
Figure 9: The minimal VBAT voltage requirement at VBAT drop

Note: Hardware power down voltage is 3.0V.

4.1.2. Monitoring Power Supply

AT command "AT+CBC" can be used to monitor the VBAT voltage. For detail, please refer to ***document [1]***.

4.2. Power on/off Scenarios

4.2.1. Power on Heracles

Customer can power on Heracles by pulling down the PWRKEY pin for more than 1 second at least and release. This pin is already pulled up to VBAT in the module internal, so external pull up is not necessary. Reference circuit is shown as below.
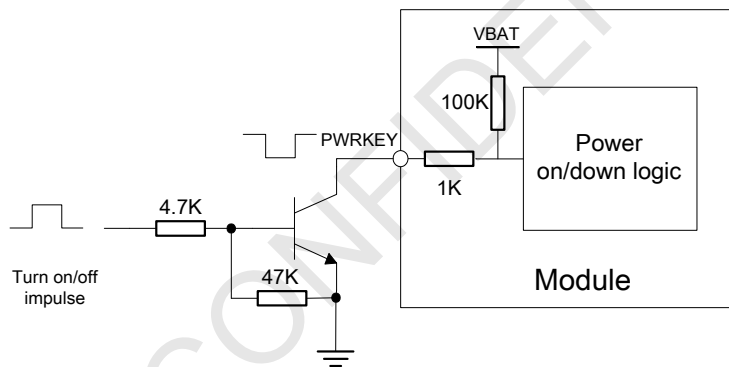
Figure 10: Powered on/off module using transistor
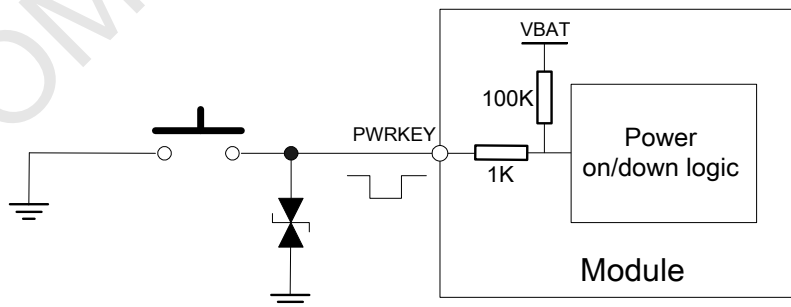
Figure 11: Powered on/off module using button

The power on timing is illustrated as in the following figure.
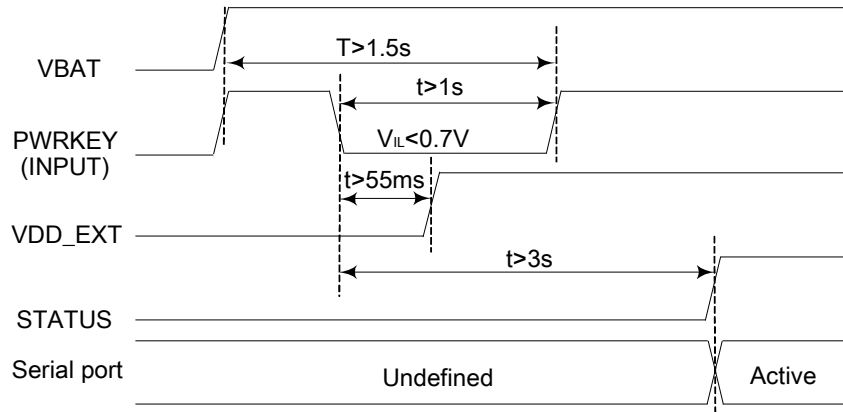
Figure 12: Timing of power on module

When power on procedure is completed, Heracles will send following URC to indicate that the module is ready to operate at fixed baud rate.

> *RDY*

This URC does not appear when autobauding function is active.

Note: Customer can use AT command "AT+IPR=x" to set a fixed baud rate and save the configuration to non-volatile flash memory. After the configuration is saved as fixed baud rate, the Code "RDY" should be received from the serial port every time when Heracles is powered on. For details, please refer to the chapter "AT+IPR" in document [1].

4.2.2. Power down Heracles

Heracles will be powered down in the following situations：

- Normal power down procedure: power down Heracles by the PWRKEY pin.
- Normal power down procedure: power down Heracles by AT command "AT+CPOWD=1".
- Abnormal power down: over-voltage or under-voltage automatic power down.

4.2.2.1. Power down Heracles by the PWRKEY Pin

Customer can power down Heracles by pulling down the PWRKEY pin for at least 1.5 second and release. Please refer to the power on circuit. The power down timing is illustrated in the following figure.
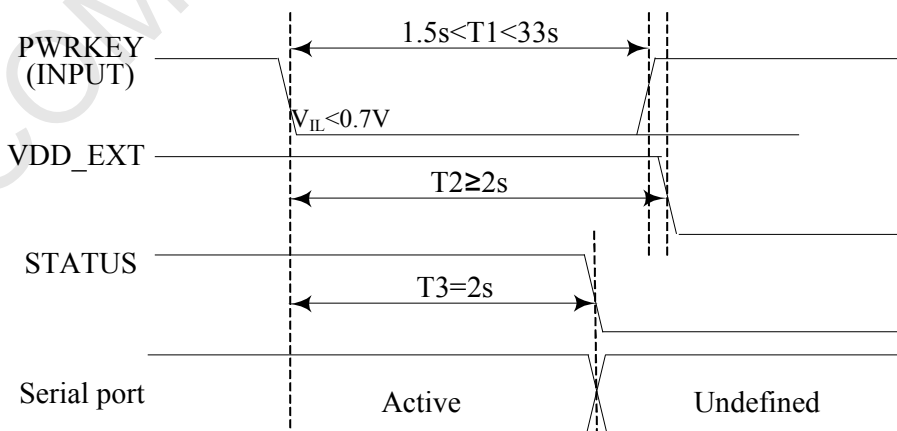
Figure 13: Timing of power down Heracles by PWRKEY

This procedure makes the module log off from the network and allows the software to enter into a secure state to save data before completely shut down. Before the power down procedure, the module will send URC:

> *NORMAL POWER DOWN*

At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS or VDD_EXT, which is at low level at this time.

4.2.2.2. Power down Heracles by AT Command

Heracles can be powered down by AT command "AT+CPOWD=1". This procedure makes the module log off from the network and allows the software to enter into a secure state to save data before completely shut down. Before the completion of the power down procedure, the module will send URC:

NORMAL POWER DOWN

At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS or VDD_EXT, which is at low level at this time.

Note:For detail about AT command "AT+CPOWD", please refer to document [1].

4.2.2.3. Over-Voltage or Under-Voltage Power Down

The module software monitors the VBAT voltage constantly.

If the voltage ≤ 3.5V, the following URC will be reported:

UNDER-VOLTAGE WARNNING

If the voltage ≥ 4.3V, the following URC will be reported:

OVER-VOLTAGE WARNNING

If the voltage < 3.4V, the following URC will be reported, and the module will be automatically powered down.

UNDER-VOLTAGE POWER DOWN

If the voltage > 4.4V, the following URC will be reported, and the module will be automatically powered down.

OVER-VOLTAGE POWER DOWN

At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS or VDD_EXT, which is at low level at this time.

Note：The default over voltage or under voltage power down is disable, AT command "AT+CBATCHK=1" could be used to open this function, digital interface characteristics should refer to table 38 strictly. For details please refer to document [1].

4.2.2.4. Restart Heracles by PWRKEY Pin:

When the module works normally, if the customer wants to restart the module, the time after STATUS pin changed to low should be at least 800ms. The module needs enough time to power down completely.
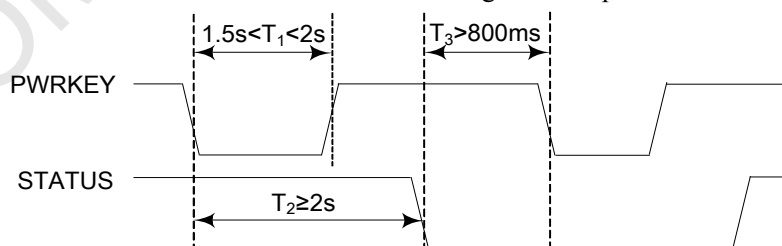
Figure 14: Timing of restart Heracles

Note：The figure 14 is based on that the powerkey pin is pulled down from 1.5s to 2s. The status should keep low more than 800ms before next restart.

4.2.3. Reset Function

Heracles also has a RESET pin (pin 49) used to reset the module. This function is used as an emergency reset

only when AT command "AT+CPOWD=1" and the PWRKEY pin has no effect. Customer can pull the RESET pin to ground, then the module will reset.

This pin is already isolated in the module, so the external isolation is not necessary. Following figure is internal circuit of the RESET pin.
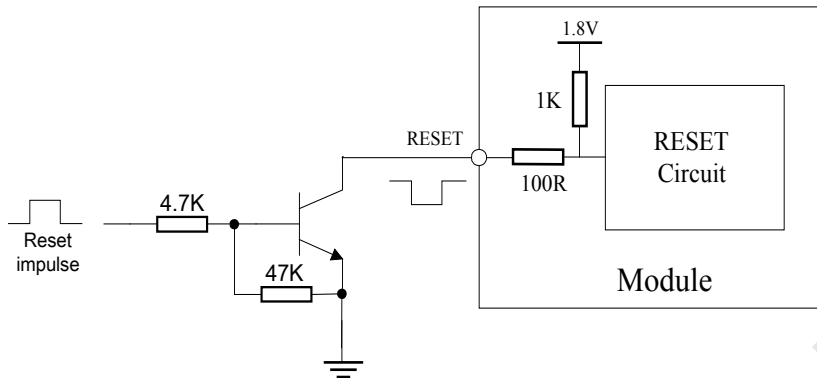
Figure 15: Reset module using transistor
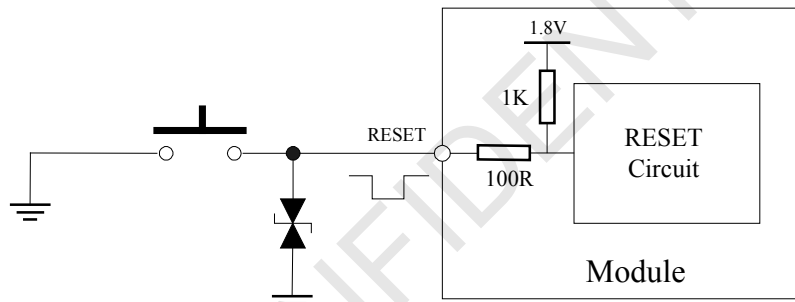
Figure 16: Reset module using button

The typical value of RESET pin at High level is 1.8V, RESET hardware parameters can refer to the table below:

Table 7: Electronic characteristic of the RESET pin

Pin name	Symbol	Min	Typ	Max	Unit
RESET	V_{IH}	1.5	1.8	2.0	V
	V_{IL}	-	-	0.6	V
	Low power time	105		-	ms

The reset scenarios are illustrated in the following figures.
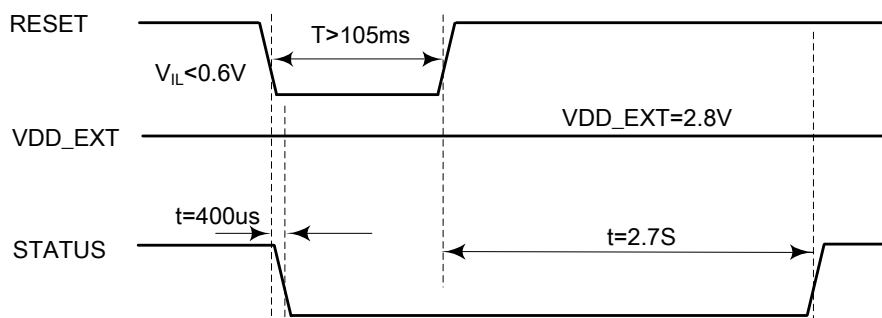
Figure 17: Reset timing sequence

4.3. Power Saving Mode

Heracles has two power saving modes: Minimum functionality mode and sleep mode. AT command "AT+CSCLK=1"can be used to set Heracles into sleep mode. AT command "AT+CFUN=<fun>" can be used to set Heracles into minimum functionality. When Heracles is in sleep mode and minimum functionality mode, the current of module is lowest.

4.3.1. Minimum Functionality Mode

There are three functionality modes, which could be set by AT command "AT+CFUN=<fun>". The command provides the choice of the functionality levels <fun>=0,1,4.

- AT+CFUN=0： Minimum functionality.
- AT+CFUN=1： Full functionality (default).
- AT+CFUN=4： Flight mode (disable RF function).

Table 8: The current consumption of Minimum Functionality Mode(AT+CSCLK=1)

<fun>	BS-PA-MFRMS	Current consumption in sleep mode (mA)
0	N/A	0.545
1	9	0.76
	5	0.89
	2	1.19
4	N/A	0.61

Minimum functionality mode minimizes the current consumption to the lowest level. If Heracles is set to minimum functionality by "AT+CFUN=0", the RF function will be disabled. In this case, the serial port is still accessible, but all AT commands correlative to RF function will not be accessible.

For detailed information about AT command "AT+CFUN=<fun>", please refer to *document [1]*.

4.3.2. Sleep Mode 1 (AT+CSCLK=1)

Customer can control Heracles module to enter or exit the sleep mode (AT+CSCLK=1) by DTR signal. When DTR is in high level and without interrupt (on air and hardware such as GPIO interrupt or data in serial port), Heracles will enter sleep mode automatically. In this mode, Heracles can still receive paging or SMS from network but the serial port is not accessible.

4.3.3. Wake Up Heracles from Sleep Mode 1

When Heracles is in sleep mode 1(AT+CSCLK=1), the following methods can wake up the module:
- Pull down DTR pin.
  The serial port will be active after DTR pin is pulled to low level for about 50ms.
- Receive a voice or data call from network.
- Receive a SMS from network.
- Receive external interrupt.

Note: After module has received incoming call or new SMS, serial port can report URC, but the serial port can not input AT command. Only after the DTR pin is pulled to low level for 50ms, the serial port can input AT command.

4.3.4. Sleep Mode 2 (AT+CSCLK=2)

In this mode, Heracles will continuously monitor the serial port data signal. When there is no data transfer over 5 seconds on the RXD signal and there is no on air and hardware interrupts (such as GPIO interrupt), Heracles will enter sleep mode 2 automatically. In this mode, Heracles can still receive paging or SMS from network .

4.3.5. Wake Up Heracles from Sleep Mode 2

When Heracles is in sleep mode 2 (AT+CSCLK=2), the following methods can wake up the module:
- Send data to Heracles via main serial port (the first character will lose).
- Receive a voice or data call from network.
- Receive a SMS from network.

Note: Autobauding is default. It cannot enter sleep mode in the absence of synchronous serial port baud rate after module power on.

4.4. RTC Backup

Current input for RTC when the VBAT is not supplied for the system. Current output for backup battery when the VBAT power supply is in present and the backup battery is in low voltage state. The RTC power supply of module can be provided by an external capacitor or a battery (non-chargeable or rechargeable) through the VRTC. The following figures show various reference circuits for RTC back up.

- **External capacitor backup**
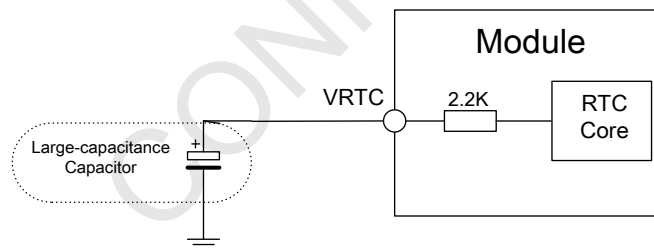
Figure 18: RTC supply from capacitor

- **Non-chargeable battery backup**
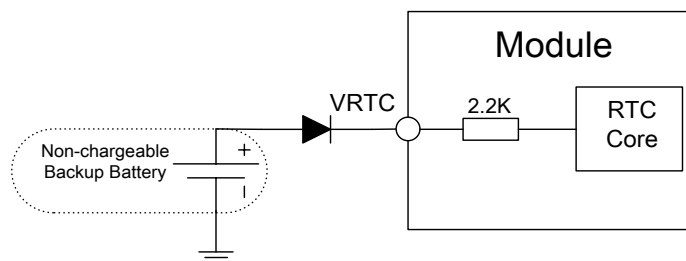
Figure 19: RTC supply from non-chargeable battery

- **Rechargeable battery backup**
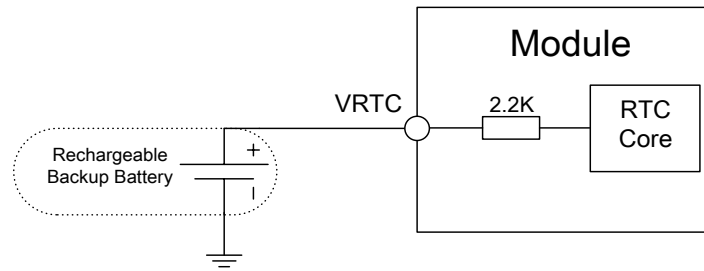
Figure 20: RTC supply from rechargeable battery

Note: The clock error becomes larger when VBAT is turned off and RTC circuit was supplied from the backup battery or the external capacitor.

4.5. Serial Port and USB Interface

Heracles default provides one unbalanced asynchronous serial ports. The module is designed as a DCE (Data Communication Equipment). The following figure shows the connection between module and client (DTE).

Table 9: Serial port and USB pin definition

	Pin name	Pin number	Function
Serial port	DTR	69	Data terminal ready
	RI	68	Ring indicator
	DCD	70	Data carrier detect
	CTS	34	Request to send
	RTS	33	Clear to send
	TXD	32	Transmit data
	RXD	31	Receive data
Debug port	VBUS	7	USB power supply
	USB_DP	59	USB data line positive
	USB_DN	19	USB data line negative

Note: Hardware flow control is disable by default. AT command "AT+IFC=2,2"can enable hardware flow control. AT command "AT+IFC=0,0"can disable hardware flow control. For more details please refer to document [1].

Table 10: Serial port characteristics

Symbol	Min	Typ	Max	Unit
V_{IL}	-0.3	-	0.7	V
V_{IH}	2.1	-	3.1	V
V_{OL}	-	-	0.4	V
V_{OH}	2.4	2.8	-	V

4.5.1 Function of Serial Port

Serial port:

- Full mode device.
- Contains data lines TXD and RXD, hardware flow control lines RTS and CTS, status lines DTR, DCD and RI.
- Serial port can be used for CSD FAX, GPRS service and AT communication. It can also be used for multiplexing function. For details about multiplexing function, please refer to *table 11*.
- Serial port supports the following baud rates:
  1200, 2400, 4800, 9600, 19200, 38400, 57600,115200,230400 and 460800bps
- Autobauding only supports the following baud rates:
  1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200bps
- The default setting is autobauding.

Autobauding allows Heracles to automatically detect the baud rate of the host device. Pay more attention to the following requirements:

- **Synchronization between DTE and DCE:**
  When DCE powers on with autobauding enabled, it is recommended to send "AT" or "at" or "aT" or "At" to synchronize the baud rate, until DTE receives the "OK" response, which means DTE and DCE are correctly synchronized. For more information please refer to AT command "AT+IPR".
- **Restrictions of autobauding operation:**
  The DTE serial port must be set at 8 data bits, no parity and 1 stop bit.
  The URC such as "RDY", "+CFUN: 1" and "+CPIN: READY" will not be reported.

Note: Customer can use AT command "AT+IPR=x" to set a fixed baud rate and the setting will be saved to non-volatile flash memory automatically. After the configuration is set as fixed baud rate, the URC such as "RDY", "+CFUN: 1" and "+CPIN: READY" will be reported when Heracles is powered on.

4.5.2 Serial Interfaces

The following figure shows the connection between module and client (DTE).
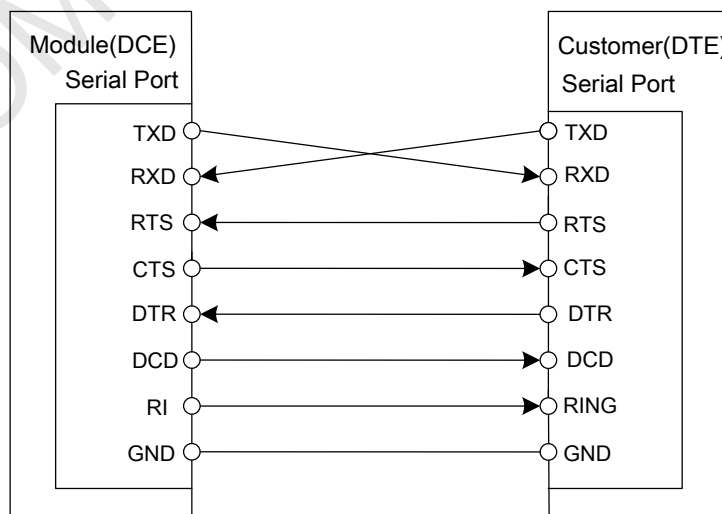
Figure 21: Connection of the serial interfaces

If the voltage of UART is 3.3V, the following reference circuits are recommended. If the voltage is 3.0V, please

change the resistors in the following figure from 5.6K to 14K.
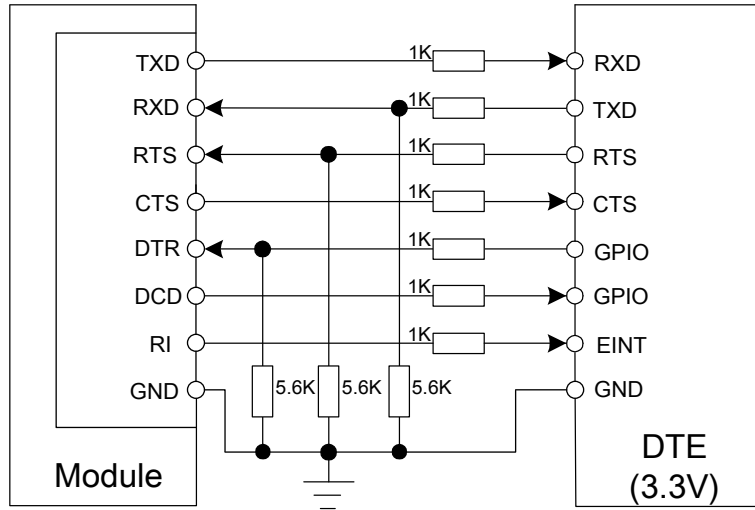
Figure 22: Resistor matching circuit

If the voltage of UART is 3V or3.3V, the following reference circuits are recommended:
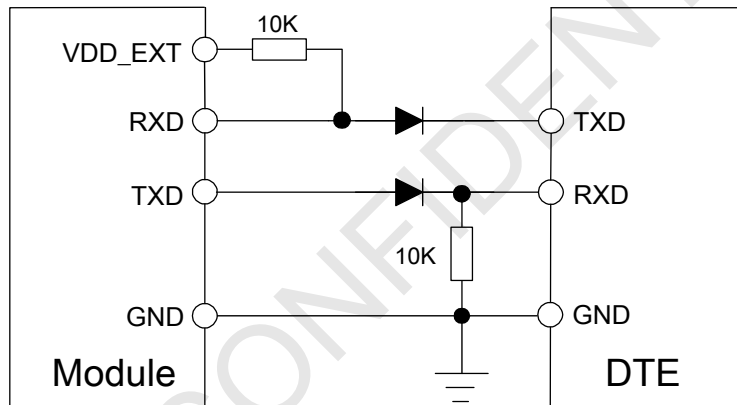
Figure 23: Diode isolation circuit

Note: please make sure the minimum of client high limit should be less than 2.8V minus the diode drop.

If the voltage of UART is 5V, the following reference circuits are recommended:
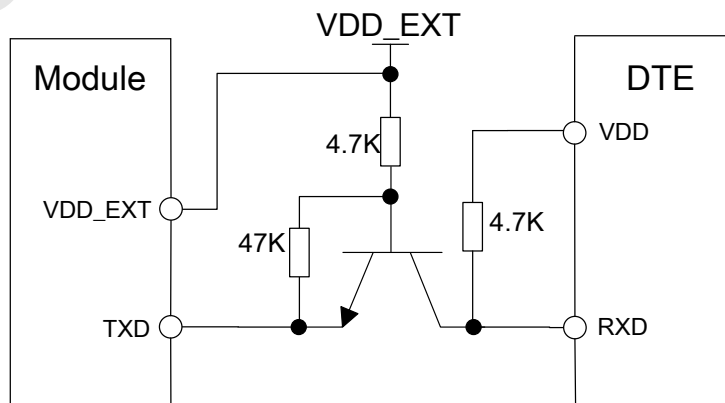
Figure 24: TX level matching circuit
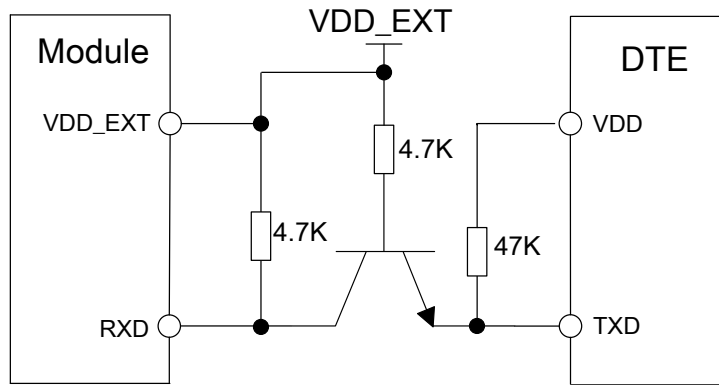
Figure 25: RX level matching circuit

Note: When Figure22, Figure 23 and Figure 24 are used for electrical level isolation, if customers use serial port to upgrade SW, please note VDD_EXT has no voltage output during the upgrading process, LDO output could be used as VDD_EXT in the figure, upgrading through USB port is recommended.

4.5.3 Debug Interface

Heracles could achieve software debug function through USB interface. When powering on the module, connect VBUS, USB_DP, USB_DN, and GND to PC, then install the driver following the prompts, a UART port could be recognized by PC, customer could achieve the software Debug with this UART port.

SIMCom recommended the following connected diagram:
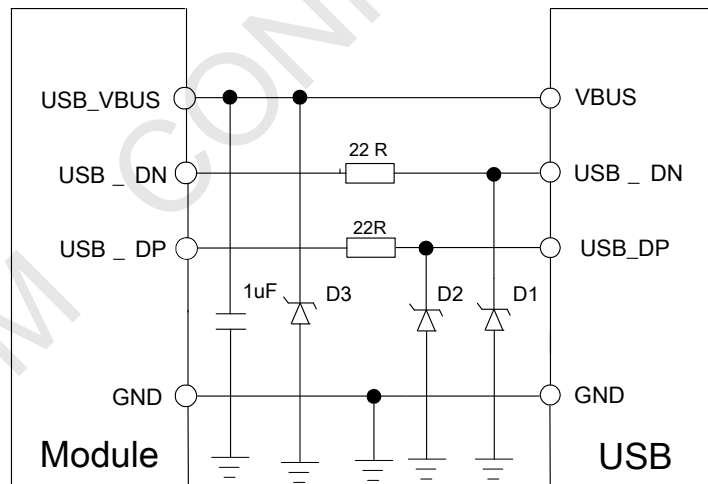
Figure 26: USB reference circuit

The TVS on USB data line should be less than 5pF, and traced by differential forms.

Note: please reserve the USB interface or test point for the further debugging

Table 11: VBUS operation voltage

Pin	Min	Typ	Max	Unit
VBUS	4.3	5.0	7	V

4.5.4   Software Upgrade

Customer could upgrade module's firmware through USB or UART interface.

If upgrading through USB interface, it is necessary to power on Heracles first, then connect VBUS, USB_DP, USB_DN, and GND to PC. There is no need to operate PWRKEY pin in the whole procedure, when Heracles detects VBUS and could communicate normally with USB_DP and USB_DN, it will enter USB download mode automatically.

If customer upgrades the software through UART interface, it is strongly recommended to lead the UART1_TXD, UART1_RXD, GND and PWRKEY pin to IO connector for the upgrading, and PWRKEY pin should connect to GND while upgrading. Refer to the following figure for debugging and upgrading software.
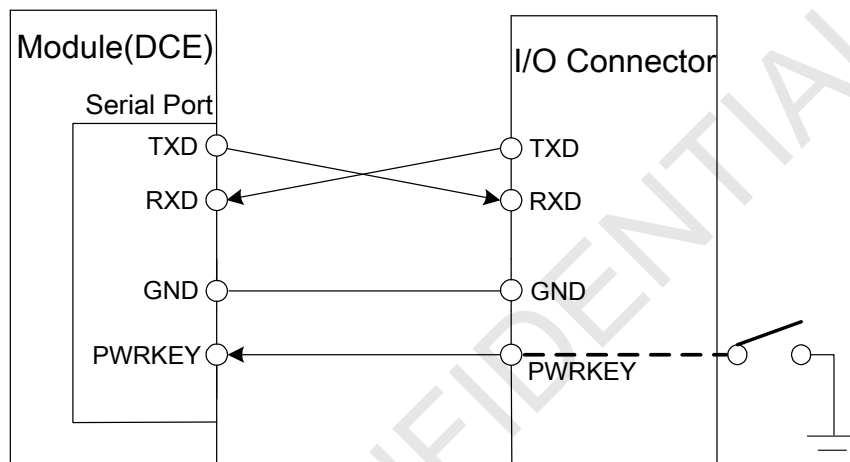
Figure 27: Connection for software upgrading and debugging

The UART interface supports the CMOS level. If customer connects the module to the computer, the level shifter should be added between the DCE and DTE.

4.6.   RI Behaviors

Table 12: RI behaviours

State	RI response
Standby	High
Voice call	The pin is changed to low. When any of the following events occur, the pin will be changed to high: （1）Establish the call （2）Hang up the call
Data call	The pin is changed to low. When any of the following events occur, the pin will be changed to high: （1）Establish the call （2）Hang up the call
SMS	The pin is changed to low, and kept low for 120ms when a SMS is received. Then it is changed to high.

URC	The pin is changed to low, and kept low for 120ms when some URCs are reported. Then it is changed to high. For more details, please refer to *document [10]*.

The behavior of the RI pin is shown in the following figure when the module is used as a receiver.
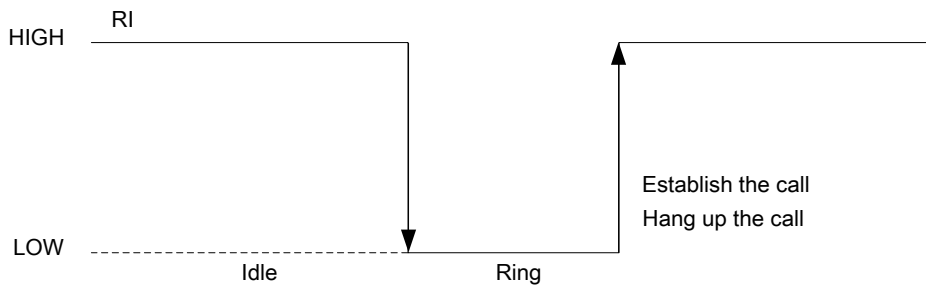
Figure 28: RI behaviour of voice calling as a receiver
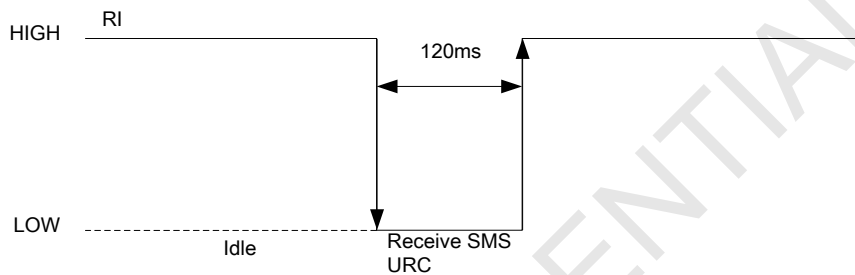
Figure 29: RI behaviour of URC or receive SMS

However, if the module is used as caller, the RI will remain high. Please refer to the following figure.
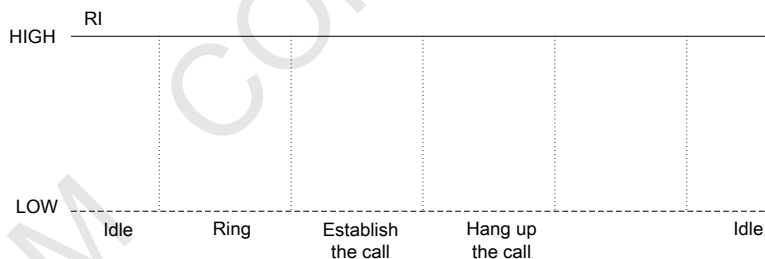
Figure 30: RI behaviour as a caller

4.7. Audio Interfaces

Heracles provides two analog inputs (MIC1P/1N; MIC2P/2N), which could be used for electret microphone. The module also provides two analog outputs (SPK1P/1N; SPK2P/2N).

Table 13: Audio interface definition

	Pin name	Pin number	Function
Main	MIC1P	52	Main Audio input positive
	MIC1N	12	Main Audio input negative
	SPK1P	53	Main Audio output positive

	SPK1N	13	Main Audio output negative
Secondary	MIC2P	9	Secondary Audio input positive
	MIC2N	10	Secondary Audio input negative
	SPK2P	51	Secondary Audio output positive
	SPK2N	11	Secondary Audio output negative

SPK1P/1N output can directly drive 32Ω receiver, Heracles internal has class-AB audio amplifier, the following table is class-AB performance:

Table 14: Performance of audio amplifier

Conditions	Class-AB AMP
4.2V 8Ω THD+N=1%	0.87W
3.4V 8Ω THD+N=1%	0.53W
4.2V 8Ω THD+N=10%	1.08W
3.4V 8Ω THD+N=10%	0.65W

SPK2P/2N output can directly drive 8Ω speaker.

AT command "AT+CMIC" is used to adjust the input gain level of microphone. AT command "AT+SIDET" is used to set the side-tone level. In addition, AT command "AT+CLVL" is used to adjust the output gain level. For more details, please refer to *document [1]*.

In order to improve audio performance, the following reference circuits are recommended. The audio signals have to be layout according to differential signal layout rules as shown in following figures.

4.7.1. Speaker Interfaces Configuration
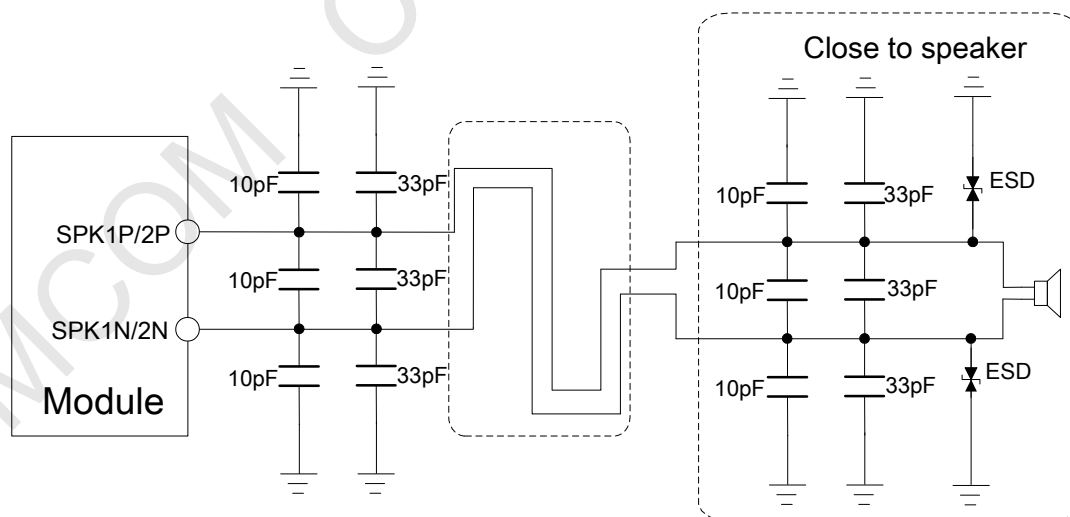
Figure 31: Speaker reference circuit

4.7.2. Microphone Interfaces Configuration
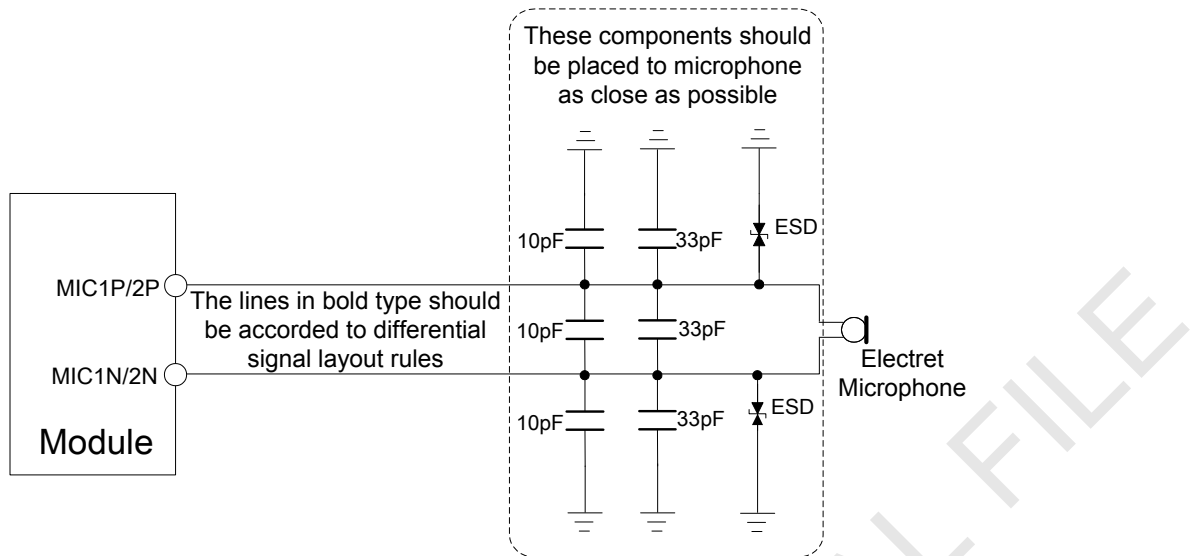
Figure 32: Speaker with amplifier reference circuit

4.7.3. Audio Electronic Characteristic

Table 15: Microphone input characteristics

Parameter		Min	Typ	Max	Unit
Microphone biasing voltage			1.9	2.2	V
Working current				2.0	mA
Input impedance(differential)		13	20	27	KΩ
Idle channel noise				-67	dBm0
SINAD	Input level:-40dBm0	29			dB
	Input level:0dBm0		69		dB

Table 16: Audio output characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Normal output	R_L=32 Ω receiver	-	90	-	mW
	R_L=8 Ω speaker	-	-	1080	mW

4.7.4. TDD

Audio signal could be interferenced by RF signal. Coupling noise could be filtered by adding 33pF and 10pF capacitor to audio lines. 33pF capacitor could eliminate noise from GSM850/EGSM900MHz, while 10pF capacitor could eliminate noise from DCS1800/PCS1900MHz frequency. Customer should develop this filter solution according to field test result.

GSM antenna is the key coupling interfering source of TDD noise. Thereat, pay attention to the layout of audio lines which should be far away from RF cable, antenna and VBAT pin. The bypass capacitor for filtering should be placed near module and another group needs to be placed near to connector.

Conducting noise is mainly caused by the VBAT drop. If audio PA was powered by VBAT directly, then there

will be some cheep noise from speaker output easily. So it is better to put big capacitors and ferrite beads near audio PA input.

TDD noise has something to do with GND signal. If GND plane is not good, lots of high-frequency noises will interference microphone and speaker over bypass capacitor. So a good GND during PCB layout could avoid TDD noise.

4.8. SIM Card Interface

The SIM interface complies with the GSM Phase 1 specification and the new GSM Phase 2+ specification for FAST 64 kbps SIM card. Both 1.8V and 3.0V SIM card are supported. The SIM interface is powered from an internal regulator in the module.

4.8.1. SIM Card Application

Table 17: SIM pin definition

Pin name	Pin number	Function
SIM_VDD	16	Voltage supply for SIM card. Support 1.8V or 3V SIM card
SIM_DATA	14	SIM data input/output
SIM_CLK	55	SIM clock
SIM_RST	15	SIM reset

It is recommended to use an ESD protection component such as ST (www.st.com) ESDA6V1-5W6 or ON SEMI (www.onsemi.com) SMF05C. That the SIM peripheral circuit should be close to the SIM card socket. The reference circuit of the 8-pin SIM card holder is illustrated in the following figure.
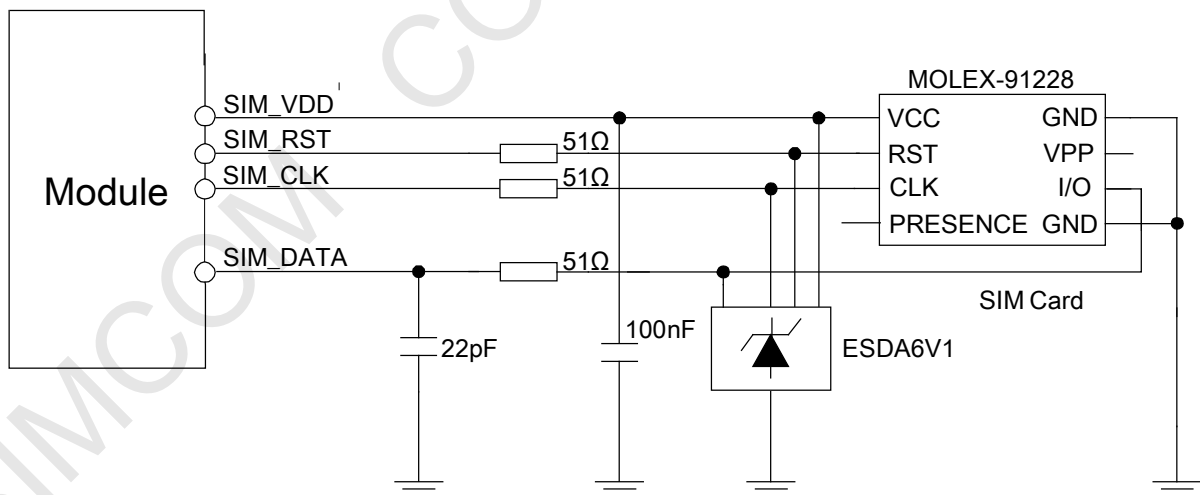
Figure 33: Reference circuit of the 8-pin SIM card holder

The reference circuit of 6-pin SIM card holder is illustrated in the following figure.
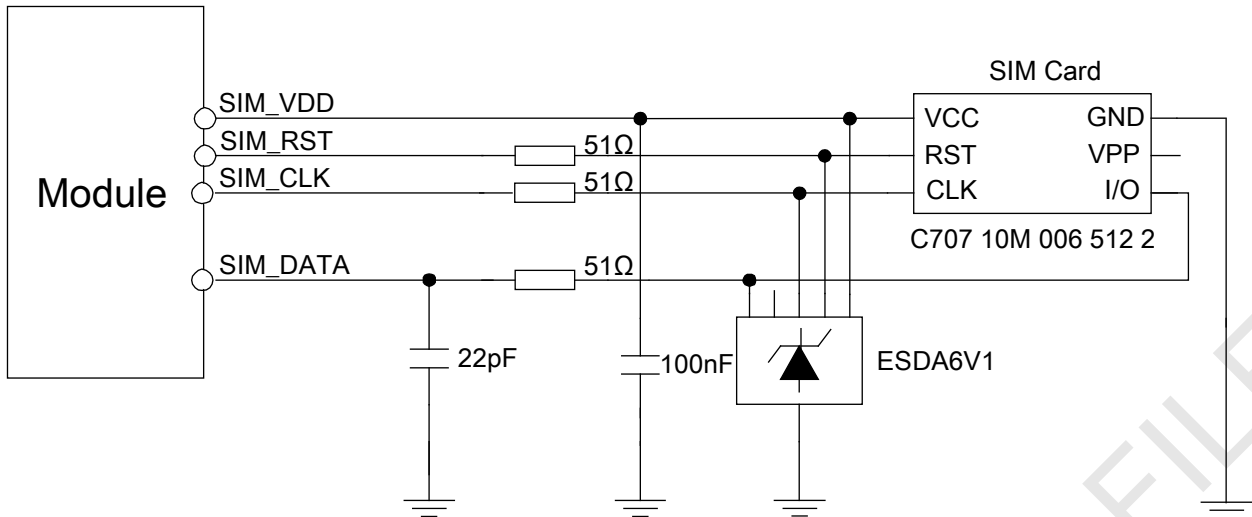
Figure 34: Reference circuit of the 6-pin SIM card holder

4.8.2. SIM Card Design Guide

SIM card signal could be interferenced by some high frequency signal, it is strongly recommended to follow these guidelines while designing:

- SIM card holder should be far away from GSM antenna
- SIM traces should keep away from RF lines, VBAT and high-speed signal lines
- The traces should be as short as possible
- Keep SIM card holder's GND connect to main ground directly
- Shielding the SIM card signal by ground well
- Recommended to place a 100nF capacitor on SIM_VDD line and keep close to the SIM card holder
- Add some TVS which parasitic capacitance should not exceed 50pF
- Add 51Ω resistor to (SIM_RST/SIM_CLK/SIM_DATA) signal could enhance ESD protection

4.8.3. Design Considerations for SIM Card Holder

For 8 pins SIM card holder, SIMCom recommends to use Molex 91228.Customer can visit http://www.molex.com for more information about the holder.
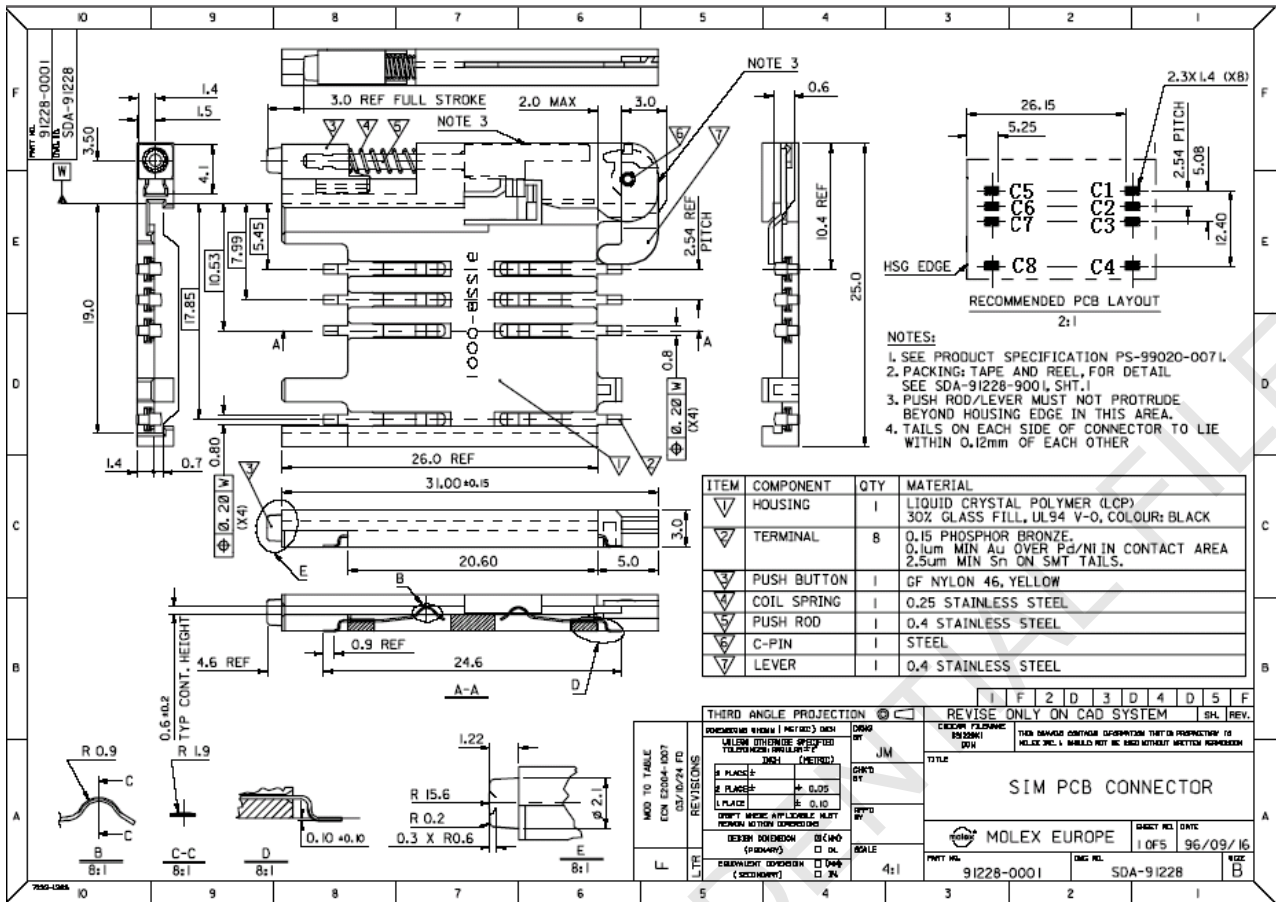
Figure 35: Molex 91228 SIM card holder

Table 18: Pin description (Molex SIM card holder)

Pin name	Signal	Description
C1	SIM_VDD	SIM card power supply
C2	SIM_RST	SIM card reset
C3	SIM_CLK	SIM card clock
C4	GND	Connect to GND
C5	GND	Connect to GND
C6	VPP	Not connect
C7	SIM_DATA	SIM card data I/O
C8	SIM_DET	Detect SIM card presence

For 6-pin SIM card holder, SIMCom recommends to use Amphenol C707 10M006 512 .Customer can visit http://www.amphenol.com for more information about the holder.
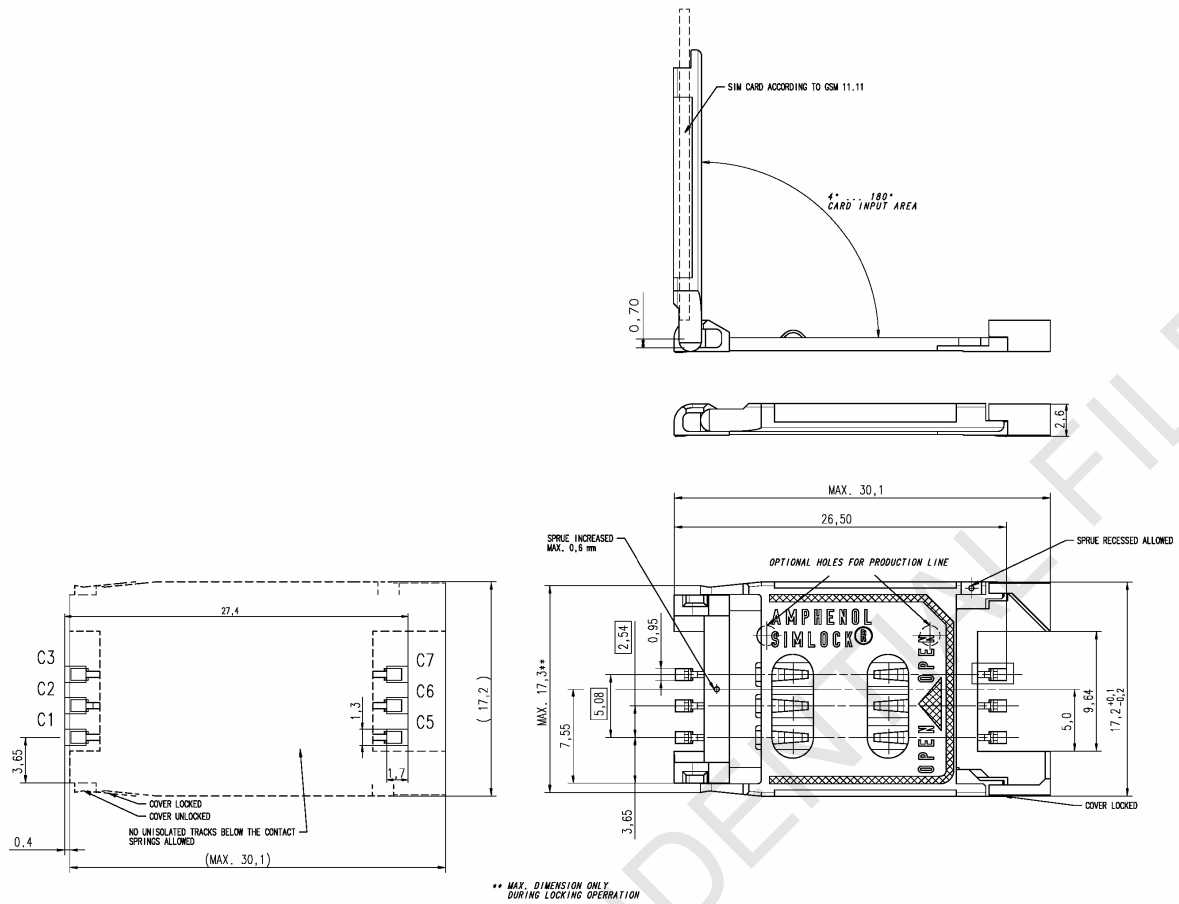
Figure 36: Amphenol C707 10M006 512 SIM card holder

Table 19: Pin description (Amphenol SIM card holder)

Pin name	Signal	Description
C1	SIM_VDD	SIM card power supply
C2	SIM_RST	SIM card reset
C3	SIM_CLK	SIM card clock
C5	GND	Connect to GND
C6	VPP	Not connect
C7	SIM_DATA	SIM card data I/O

Note: Every time plug SIM card interval advice is greater than 2s. Otherwise may not be able to correct detection.

Customer can use AT command "AT+SSIM" to use SIM card, For detail, please refer to document [1].

4.9. PCM Interface

Heracles provides a hardware PCM interface:

Table 20: PCM pin definition

Pin name	Pin number	Description

PCM_CLK	29	PCM clock
PCM_OUT	30	PCM data output
PCM_SYNC	65	PCM synchrony
PCM_IN	66	PCM data input

Heracles PCM interface only supply master mode, data length is 16 bits (linear)，PCM clock rate is 256KHz.

Table 21: PCM specification

Parameter	Specification
Line Interface Format	Linear(Fixed)
Data length	16bits(Fixed)
PCM Clock/Sync Source	Master Mode(Fixed)
PCM Clock Rate	256KHz(Fixed)
PCM Sync Format	Short sync/Long sync both support
Zero Padding/Sign extension	Zero Padding(Fixed)
Data Ordering	MSB/LSB both support

Note: Customer can use AT command control PCM interface. For detail, please refer to document [1].

4.9.1. PCM Interface
Refer to the following figure for PCM design:
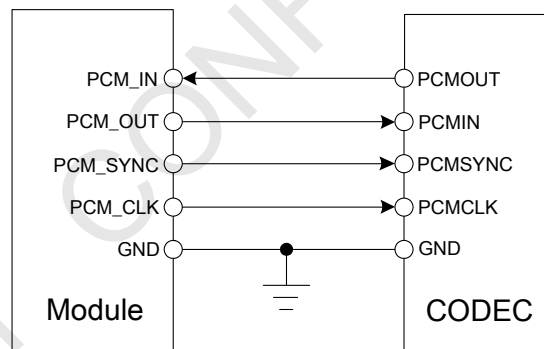
Figure 37: PCM reference circuit

4.10. Keypad Interface

The keypad interface consists of 5 keypad column outputs and 5 keypad row inputs. with total 5*5*2, which is 50 keys. Module has two connections, which supports 25 keys and anther supports 50 keys.
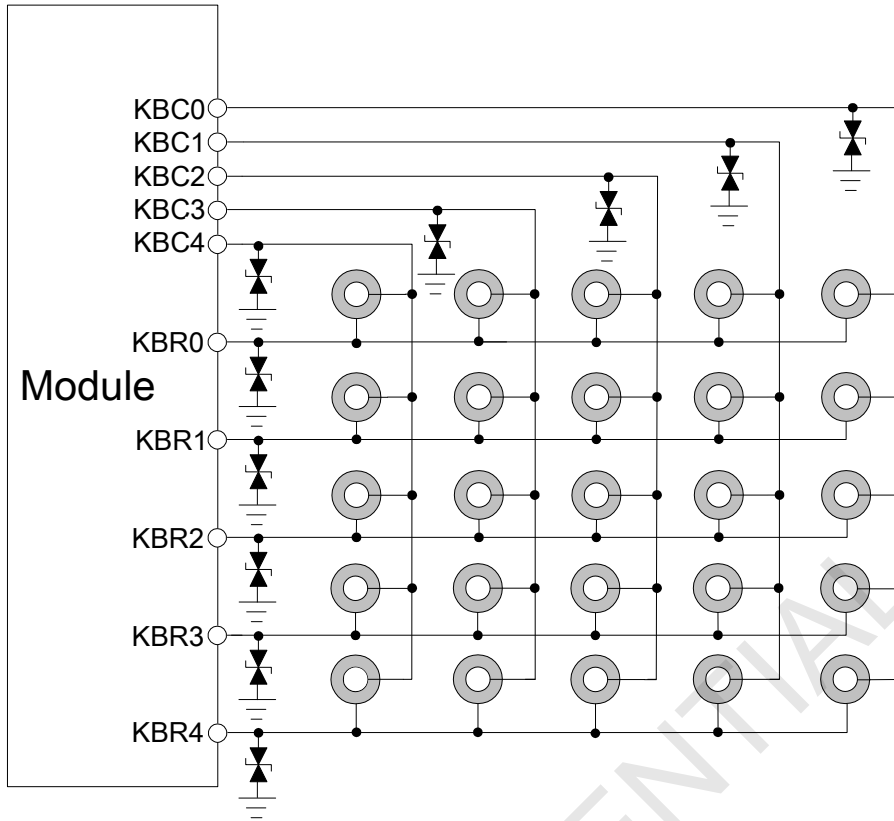
Figure 38: 25 keys reference circuit

Note：According to the traditional 5*5 to design buttons, when there is spare KBC or KBR, customer can execute AT command to define as GPIO for details please see the relevant manuals.

Module supports a new key connection, can support 50 keys, which meets full keyboard demand, the connection diagram is as following:
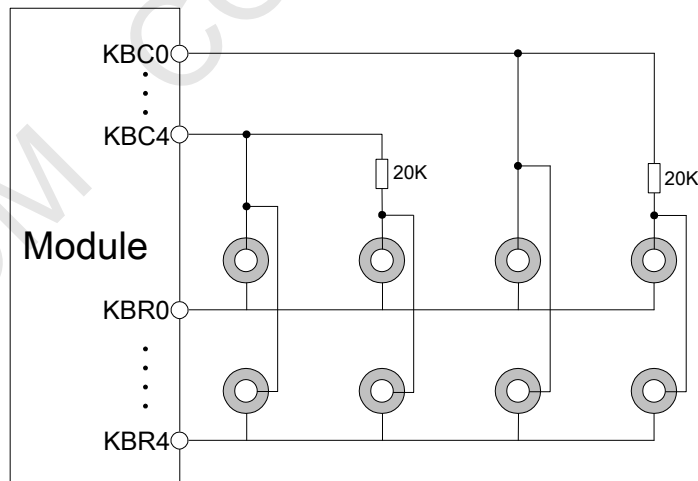
Figure 39: 50 keys reference circuit

Note：Do not change the 20KΩ resistor in the diagram.

Customer could cascade a less than 1K resistor to enhance the ESD performance, the connection diagram is as following:
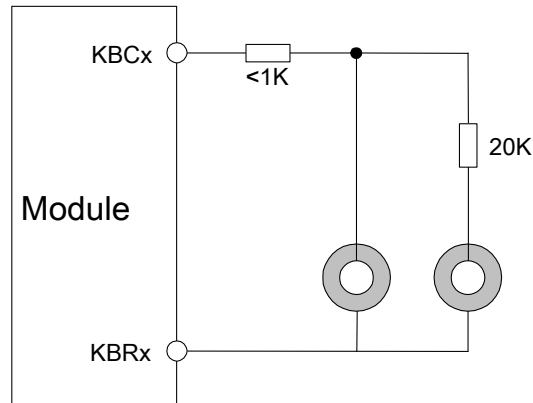
Figure 40: Keypad reference circuit

Whether using a 5*5 keys or 5*5*2 keys, the module can also detect the two buttons pressed. But when using a 5*5*2 button, the same row, column two buttons pressed at the same time can't be detected, as shown below:
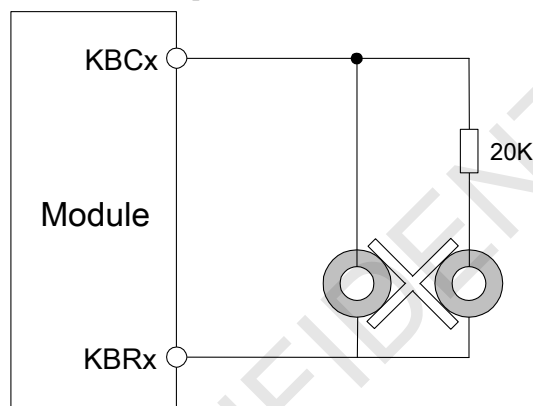
Figure 41: Keypad detected

Table 22: Pin definition of the keypad interface

Pin name	Pin number	Function	Default state
KBC0	20		Pull up
KBC1	25		Pull up
KBC2	22	Keypad matrix column	Pull up
KBC3	21		Pull up
KBC4	24		Pull up
KBR0	62		Pull down
KBR1	60		Pull down
KBR2	61	Keypad matrix row	Pull down
KBR3	23		Pull down
KBR4	63		Pull down

Note: Please be sure to increase the ESD protection devices in product design phase, and make sure have ESD protection devices in the final product.

4.11. I2C Bus

The Heracles provides an I2C interface which is only used in the embedded AT application.

- The highest data rate is 400kbit/s
- Automatic start and stop bits
- Generated response and confirmation automatically
- Application hardware I2C protocol

Table 23: Pin definition of the I2C

Pin name	Pin number	Description
SCL	74	I2C serial bus clock(open drain output)
SDA	75	I2C serial bus data(open drain output)

Notes:

1. This function is not supported in the standard firmware. If customer wants this function, the firmware must be customized. Please contact SIMCom for more details.

2. If customers design I2C please pull up to VDD_EXT.

4.12. General Purpose Input/Output (GPIO)

Heracles provides 3 GPIO pins. The output voltage level of the GPIO can be set by AT command "AT+SGPIO". The input voltage level of the GPIO can also be read by AT command "AT+SGPIO". For more details, please refer to *document [1]*.

Table 24: Pin definition of the GPIO

Pin name	Pin number	Reset state
GPIO1	3	I/PD
GPIO2	27	I/PU
GPIO3	28	I/PU
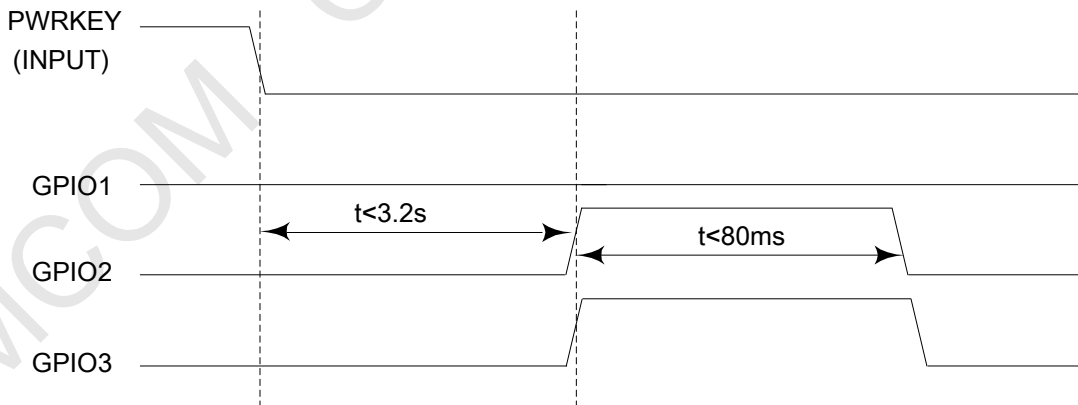
Figure 42: GPIO timing sequences

4.13. ADC

Table 25: Pin definition of the ADC

Pin name	Pin number	Description
ADC	50	Analog voltage input

Heracles provides an auxiliary ADC, which can be used to measure the voltage. Customer can use AT command "AT+CADC" to read the voltage value.

NOTE: If use the ADC function, digital interface characteristics should refer to table 38 strictly. For details of this AT command, please refer to document [1].

Table 26: ADC specification

Parameter	Min	Typ	Max	Unit
Voltage range	0	-	2.8	V
ADC Resolution	-	10	-	bits
Sampling rate	-	-	1.0833	MHz
ADC precision		10	30	mV

4.14. PWM

Table 27: Pin definition of the PWM

Pin name	Pin number	Description
PWM	26	PWM signal

Heracles provides a PWM which can be used to drive a vibrator, and a backlight LED for display or keyboard. PWM output frequency varies from 200Hz to 100KHz. Two 7-bit unsigned binary parameters are used for the output period and for the duty cycle. AT command "AT + SPWM" is used to set the output period and duty cycle of the PWM. For details, please refer to *document [1]*.

A typical recommended circuit of the PWM driver buzzer is shown in the following figure.
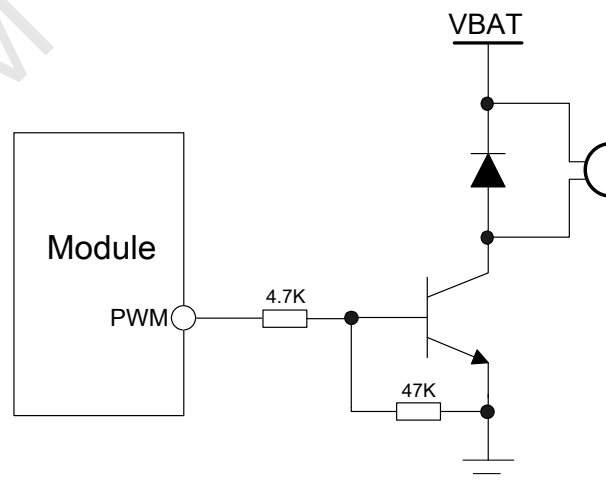
Figure 43: Reference circuit of PWM driver buzzer

Table 28: Buzzer characteristics

Parameter	Min	Typ	Max	Unit
Working voltage	2.5	2.8	2.9	V
Working current			16	mA

Note: PWM pin must be kept at low power level when module is in the power on procedure.

4.15. Network Status Indication

Table 29: Pin definition of the NETLIGHT

Pin name	Pin number	Description
NETLIGHT	64	Network Status Indication

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

Table 30: Status of the NETLIGHT pin

Status	Heracles behavior
Off	Heracles is not running
64ms On/ 800ms Off	Heracles not registered the network
64ms On/ 3000ms Off	Heracles registered to the network
64ms On/ 300ms Off	GPRS communication is established

Reference circuit is recommended in the following figure:
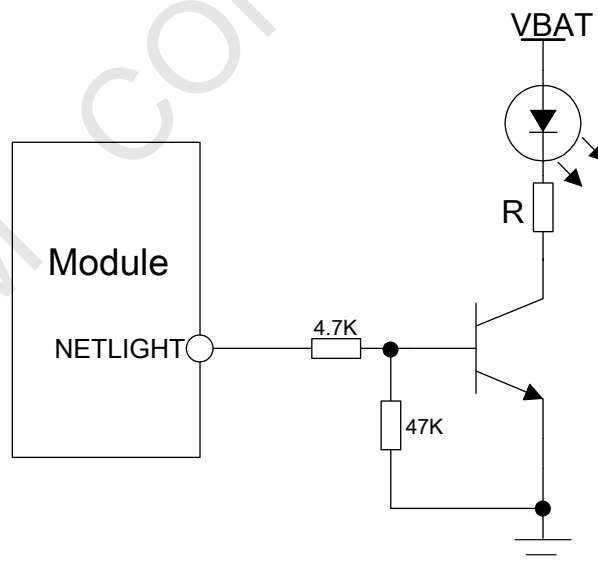
Figure 44: Reference circuit of NETLIGHT

4.16. Operating Status Indication

The pin4 is for operating status indication of the module. The pin output is high when module is powered on, and output is low when module is powered down.

Table 31: Pin definition of the STATUS

Pin name	Pin number	Description
STATUS	4	Operating status indication

Note: For timing about STATUS, please reference to the chapter "4.2 power on/down scenarios"

4.17. LED Interface

Heracles provides two LED driver pin. The two pin are open-drain output.

Table 32: Pin definition of the LED

Pin name	Pin number	Description
ISINK0	47	Sink current for LCM module
ISINK1	46	Sink current for keypad LED

Reference circuit is recommended in the following figure:
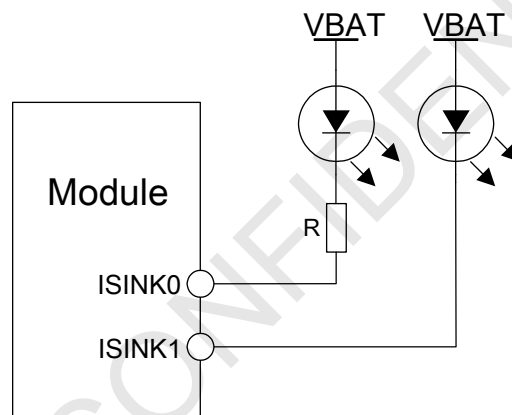
Figure 45: LED driver reference circuit

Table 33: ISINK specification

Pin name	Min	Typ	Max	Unit
ISINK0	-		24	mA
ISINK1	60	-	100	mA

Note: ISINK0 provide 6-current- level steps of up to 24mA.

4.18. RF Synchronization Signal

The synchronization signal serves to indicate growing power consumption during the transmit burst. The signal is generated by the RF_SYNC pin.

Table 34: Definition of the RF_SYNC pin

Pin name	Pin number	Description
RF_SYNC	5	Transmit synchronization signal

The timing of the synchronization signal is shown below. High level of the RF_SYNC pin indicates increased power consumption during transmission.
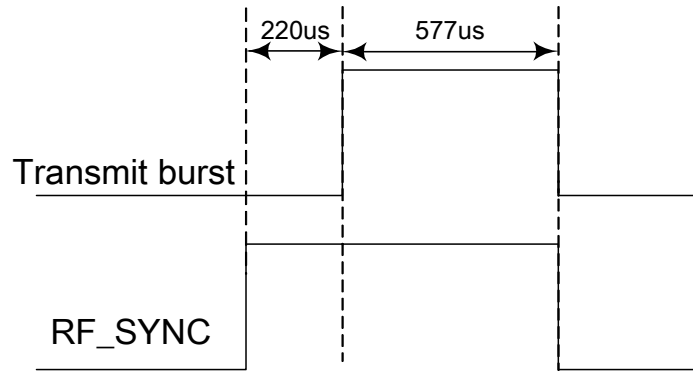
Figure 46: RF_SYNC signal during transmit burst

4.19. Antenna Interface

There are three antenna ports for Heracles GSM antenna port named GSM_ANT, The RF interface of the antenna port has an impedance of 50Ω. The input impendence of the antenna should be 50Ω, and the VSWR should be less than 2.

NOTE：About the RF trace layout please refer to "AN_SMT Module_RF_Reference Design_Guide".

4.19.1. GSM Antenna Interface

There is a GSM antenna pad named GSM_ANT for Heracles, the connection of the antenna must be decoupled from DC voltage. This is necessary because the antenna connector is DC coupled to ground via an inductor for ESD protection.

The external antenna must be matched properly to achieve best performance, so the matching circuit is necessary, the connection is recommended as following:
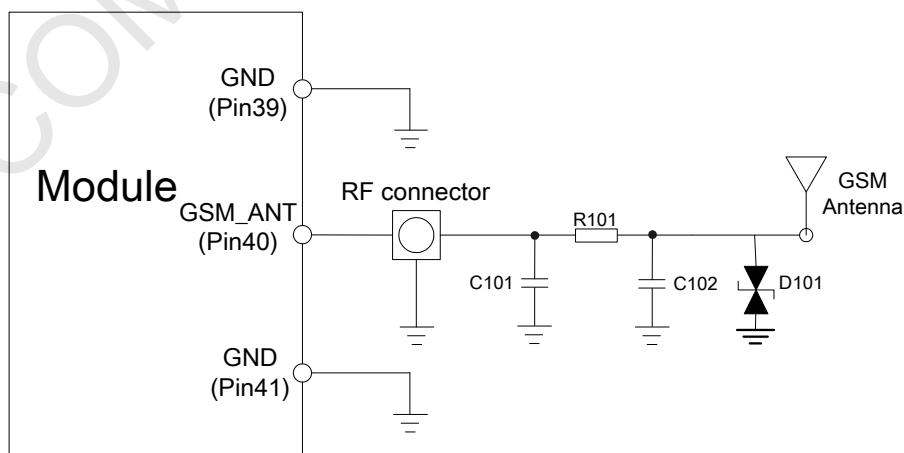
Figure 47: GSM antenna matching circuit

R101,C101,C102 are the matching circuit, the value should be defined by the antenna design. Normally R101 is 0Ω, C101 and C102 are not mounted. The RF connector is used for conduction test. If the space between RF pin

and antenna is not enough, the matching circuit should be designed as in the following figure:
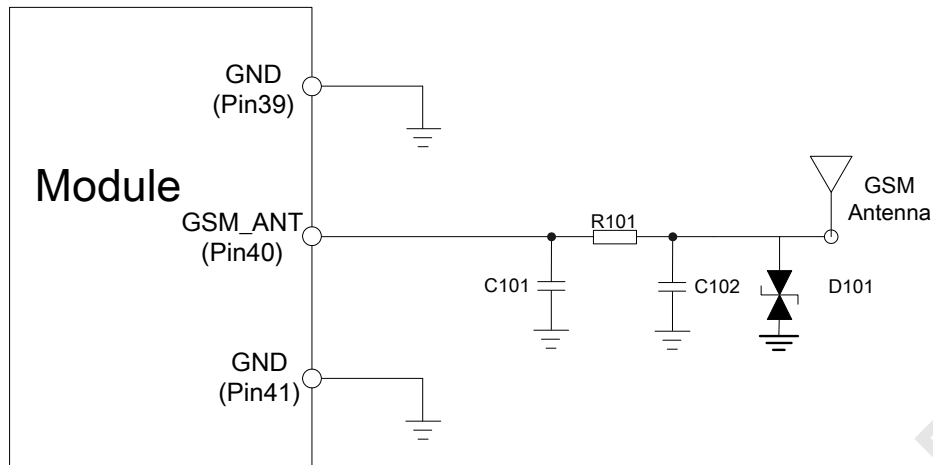
Figure 48: GSM simple antenna matching circuit

Normally R101 is 0Ω, C101 and C102 are not mounted.

D101 in Figure 46 and Figure 47 is used for ESD to protect antenna. In order to avoid damaging the module, TVS can be used. The TVS suggested can refer to Table 35.

Table 35: Recommended transient voltage suppressor

	Vendor	Part number	Packages
1	Marata	LXES03AAA1-154	0201
2	Marata	LXES15AAA1-153	0402

5. PCB Layout

Usually, most electronic products with good performance are based on good PCB layout. A bad PCB layout will lead to lots of issues, like TDD noise, etc. the final solution for these problems is to redo PCB layout. Making good PCB layout at beginning will save develop schedule and cost as well.

This section will give some guidelines on PCB layout, in order to eliminate interfere or noise by greatest degree, and save product development period.

5.1 Pin Assignment

Before PCB layout, we should learn well about pin assignment in order to get reasonable layout with so many external components. Following figure is the overview of pin assignment of the module.
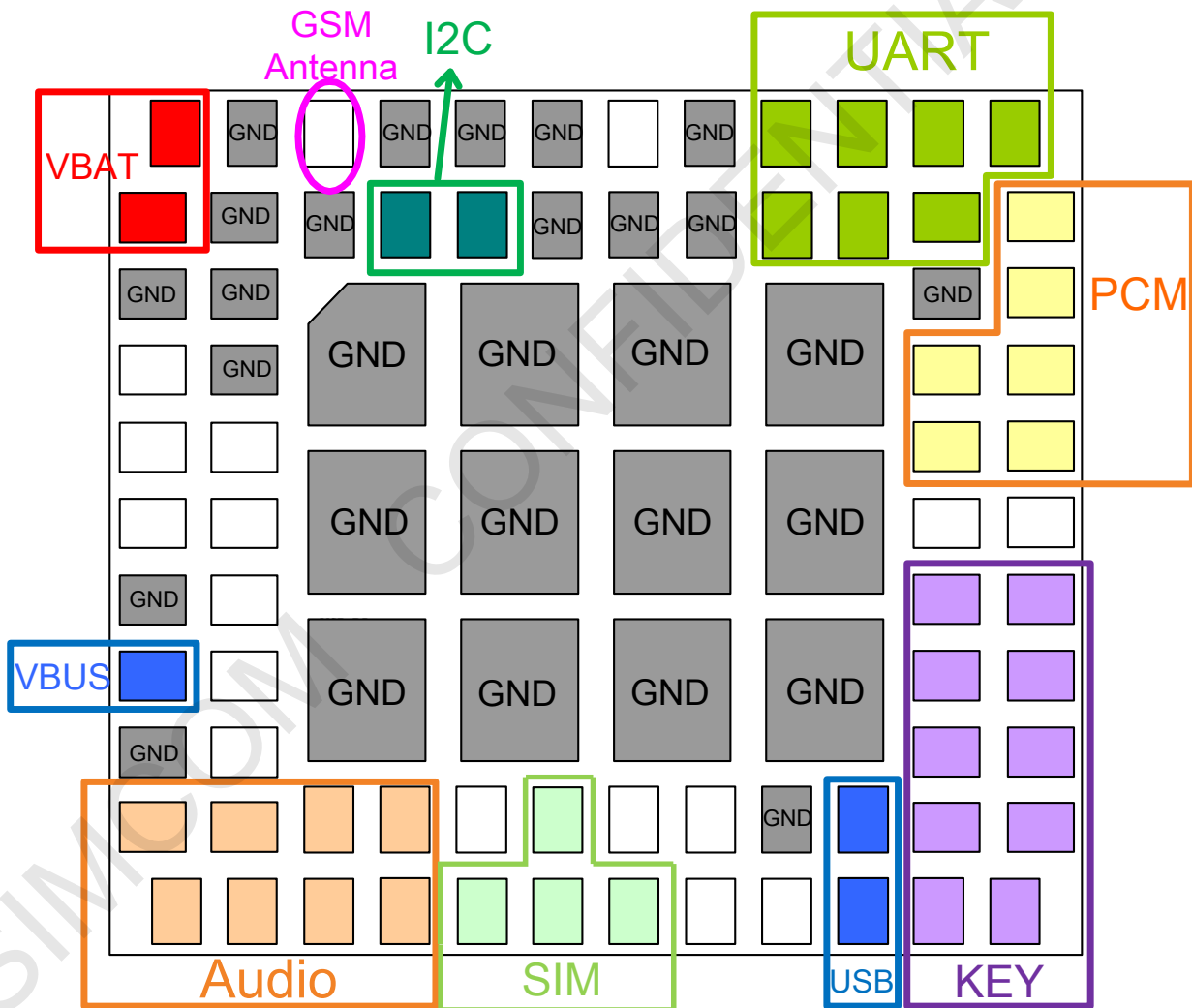
Figure 49: Pin assignment

5.2　Principle of PCB Layout

During layout, attention should be paid to the following interfaces, like Antenna, power supply, audio interface, and so on.

5.2.1.　Antenna Interface

- The length of trace between pin output and connector should be as short as possible;
- Do not trace RF signal over across the board;
- The RF signal should be far away from power ICs.

5.2.2.　Power Supply

- Not only VBAT but also return GND are very important in layout;
- The positive line of VBAT should be as short and wide as possible;
- The correct flow from source to VBAT pin should go though Zener diode then huge capacitor;
- Pin 2, Pin 43, Pin 44 and Pin45 are GND signals, and shortest layout to GND of power source should be designed;
- There are 12 GND pads in middle of module; these pads could enhance the GND performances. On the upper layer of these pads, do not trace any signal if possible.

5.2.3　SIM Card Interface

- SIM card holder has no anti-EMI component inside. Thus SIM card interface maybe interfered, please pay more attention on this interface during layout;
- Ensure SIM card holder is far way from antenna or RF cable inside;
- Put SIM card holder near the module, as nearer as possible;
- Add ESD component to protect SIM_CLK, SIM_DATA, SIM_RST and SIM_VDD signals which should be far away from power and high-speed-frequency signal.

5.2.3.　Audio Interface

- The signal trace of audio should far away from antenna and power;
- The audio signal should avoid to parallel with VBAT trace.

5.2.4.　Others

It is better to trace signal lines of UART bunched, as well as signals of USB.

5.3 Recommended PCB Layout

Based on above principles, recommended layout is shown in the following illustration.
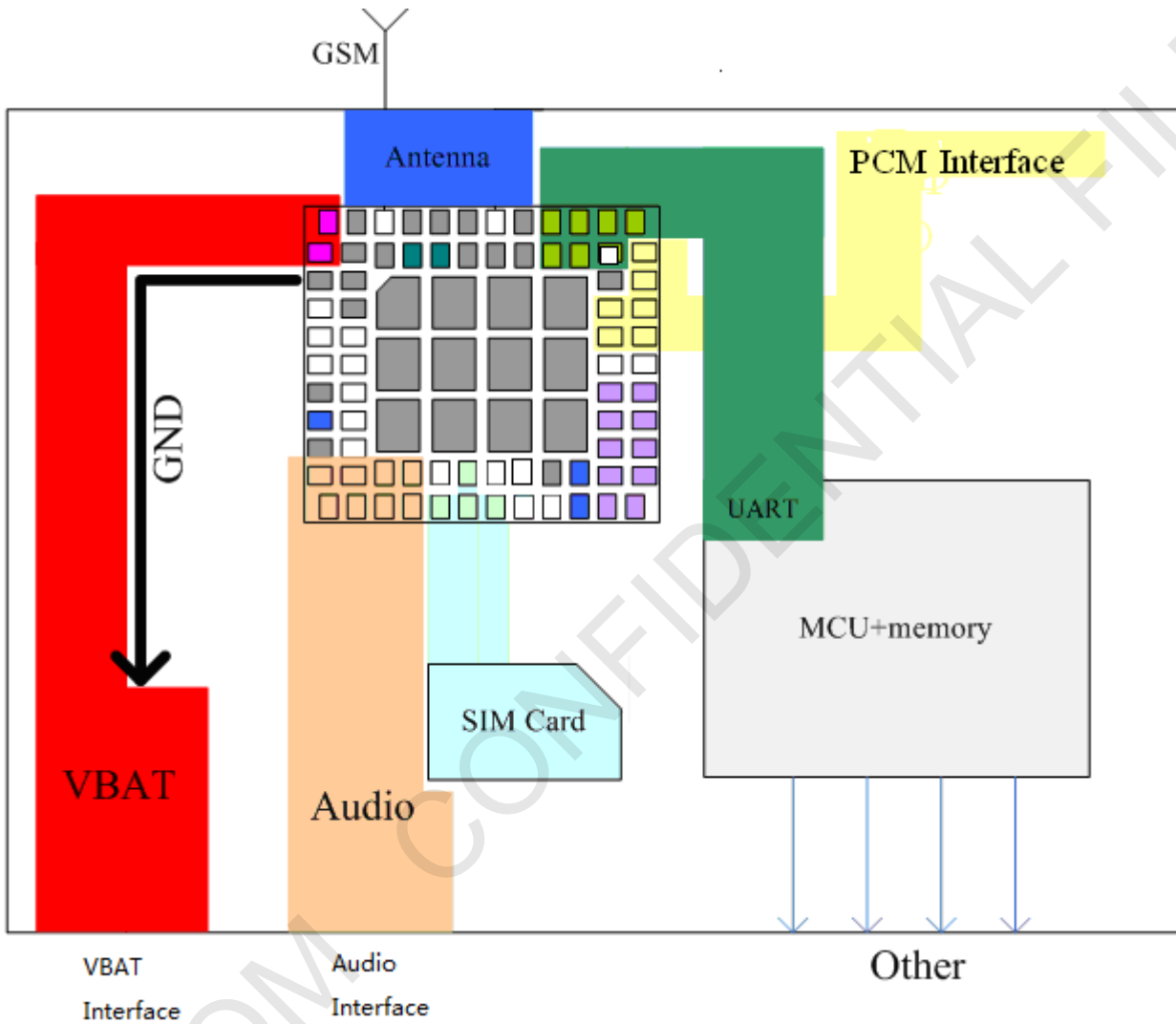
Figure 50: Recommended PCB layout

6. Electrical, Reliability and Radio Characteristics

6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in following table are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to Heracles.

Table 36: Absolute maximum ratings

Symbol	Min	Typ	Max	Unit
VBAT	-	-	4.5	V
Current	0	-	2.0	A
VBUS	-	-	7	V
I_I*	-	4	16	mA
I_O*	-	4	16	mA

*These parameters are for digital interface pins, such as keypad, GPIO, I2C, UART, and PCM.

6.2 Recommended Operating Conditions

Table 37: Recommended operating conditions

Symbol	Parameter	Min	Typ	Max	Unit
VBAT	Power supply voltage	3.4	4.0	4.4	V
VBUS	USB operating voltage	4.3	5.0	7	V
T_{OPER}	Operating temperature	-40	+25	+85	℃
T_{STG}	Storage temperature	-45		+90	℃

6.3 Digital Interface Characteristics

Table 38: Digital interface characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_{IH}	High-level input voltage	2.1	-	3.0	V
V_{IL}	Low-level input voltage	-0.3	-	0.7	V
V_{OH}	High-level output voltage	2.4	2.8	-	V
V_{OL}	Low-level output voltage	-	-	0.4	V

Note: These parameters are for digital interface pins, such as keypad, GPIO, I2C, UART, and PCM.

6.4 SIM Card Interface Characteristics

Table 39: SIM card interface characteristics

Symbol	Parameter	Min	Typ	Max	Unit
I_{IH}	High-level input current	-1.0	-	1.0	uA
I_{IL}	Low-level input current	-1.0	-	1.0	uA
V_{IH}	High-level input voltage	1.4	-	-	V
		2.4	-	-	V
V_{IL}	Low-level input voltage	-	-	0.27	V
				0.4	V
V_{OH}	High-level output voltage	1.62	-	-	V
		2.7	-	-	V
V_{OL}	Low-level output voltage	-	-	0.36	V
		-	-	0.4	V

6.5 SIM_VDD Characteristics

Table 40: SIM_VDD characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_O	Output voltage	-	3.0	-	V
		-	1.8	-	
I_O	Output current	-	-	10	mA

6.6 VDD_EXT Characteristics

Table 41: VDD_EXT characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_O	Output voltage	2.7	2.8	2.9	V
I_O	Output current	-	-	50	mA

6.7 VRTC Characteristics

Table 42: VRTC characteristics

Symbol	Description	Min	Typ	Max	Unit
V_{RTC-IN}	VRTC input voltage	1.2	2.8	3.0	V
I_{RTC-IN}	VRTC input current	-	3.0	5.0	uA
$V_{RTC-OUT}$	VRTC output voltage	-	2.8	-	V
$I_{RTC-OUT}$	VRTC output current	-	-	2.0	mA

6.8 Current Consumption (VBAT=3.8V)

Table 43: Current consumption

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VBAT	Voltage		3.4	4.0	4.4	V

	Power drop	PCL=5			232	mV
	Voltage ripple	PCL=5 @ f<200kHz			50	mV
		@ f>200kHz			2.0	mV
I_{VBAT}	Average current	Power down mode		145	200	uA
		Sleep mode (AT+CFUN=1): (BS-PA-MFRMS=9)		0.76		mA
		(BS-PA-MFRMS=5)		0.89		mA
		(BS-PA-MFRMS=2)		1.19		mA
		Idle mode (AT+CFUN=1): EGSM900		12.63		mA
		Voice call (PCL=5): GSM850		209.5		mA
		EGSM900		240		mA
		DCS1800		155		mA
		PCS1900		155.5		mA
		Data mode(1Rx,4Tx): GSM850		375		mA
		EGSM900		419.5		mA
		DCS1800		292.5		mA
		PCS1900		305		mA
		Data mode (3Rx,2Tx): GSM850		323.5		mA
		EGSM900		368.5		mA
		DCS1800		228		mA
		PCS1900		237.5		mA
		Data mode (4Rx,1Tx,): GSM850		218.5		mA
		EGSM900		246.5		mA
		DCS1800		162.5		mA
		PCS1900		168.5		mA
I_{MAX}	Peak current	During Tx burst			2.0	A

Note: In above table the current consumption value is the typical one of the module tested in laboratory. In the mass production stage, there may be differences among each individual.

6.9 Electro-Static Discharge

Heracles is an ESD sensitive component, so attention should be paid to the procedure of handling and packaging. The ESD test results are shown in the following table.

Table 44: The ESD characteristics (Temperature: 25℃, Humidity: 45 %)

Pin name	Contact discharge	Air discharge
VBAT	±5KV	±10KV
GND	±6KV	±12KV

RXD, TXD	±4KV	±8KV
Antenna port	±5KV	±10KV
SPK_P/SPK_N/MIC_P/MIC_N	±4KV	±8KV
PWRKEY	±4KV	±8KV

6.10 Radio Characteristics

6.10.1. Module RF Output Power

The following table shows the module conducted output power, it is followed by the 3GPP TS 05.05 technical specification requirement.

Table 45: GSM850 and EGSM900 conducted RF output power

PCL	Nominal output power (dBm)	Tolerance (dB) for conditions	
		Normal	Extreme
5	33	±2	±2.5
6	31	±3	±4
7	29	±3	±4
8	27	±3	±4
9	25	±3	±4
10	23	±3	±4
11	21	±3	±4
12	19	±3	±4
13	17	±3	±4
14	15	±3	±4
15	13	±3	±4
16	11	±5	±6
17	9	±5	±6
18	7	±5	±6
19-31	5	±5	±6

Table 46: DCS1800 and PCS1900 conducted RF output power

PCL	Nominal output power (dBm)	Tolerance (dB) for conditions	
		Normal	Extreme
0	30	±2	±2.5
1	28	±3	±4
2	26	±3	±4
3	24	±3	±4
4	22	±3	±4

5	20	±3	±4
6	18	±3	±4
7	16	±3	±4
8	14	±3	±4
9	12	±4	±5
10	10	±4	±5
11	8	±4	±5
12	6	±4	±5
13	4	±4	±5
14	2	±5	±6
15	0	±5	±6

6.10.2.   Module RF Receive Sensitivity

The following table shows the module's conducted receiving sensitivity, it is tested under static condition.

Table 47: Conducted RF receive sensitivity

Frequency	Receive sensitivity（Typical）	Receive sensitivity(Max)
GSM850,EGSM900	< -108dBm	< -106dBm
DCS1800,PCS1900	< -108dBm	< -106dBm

6.10.3.   Module Operating Frequencies

The following table shows the module's operating frequency range; it is followed by the 3GPP TS 05.05 technical specification requirement.

Table 48: Operating frequencies

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

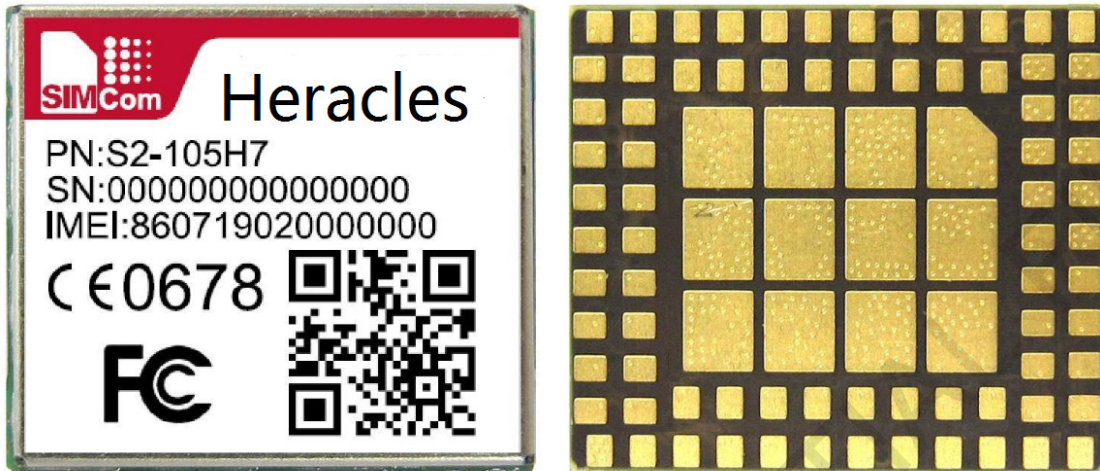# 7. Manufacturing

7.1. Top and Bottom View of Heracles

Figure 51: Top and bottom view of Heracles

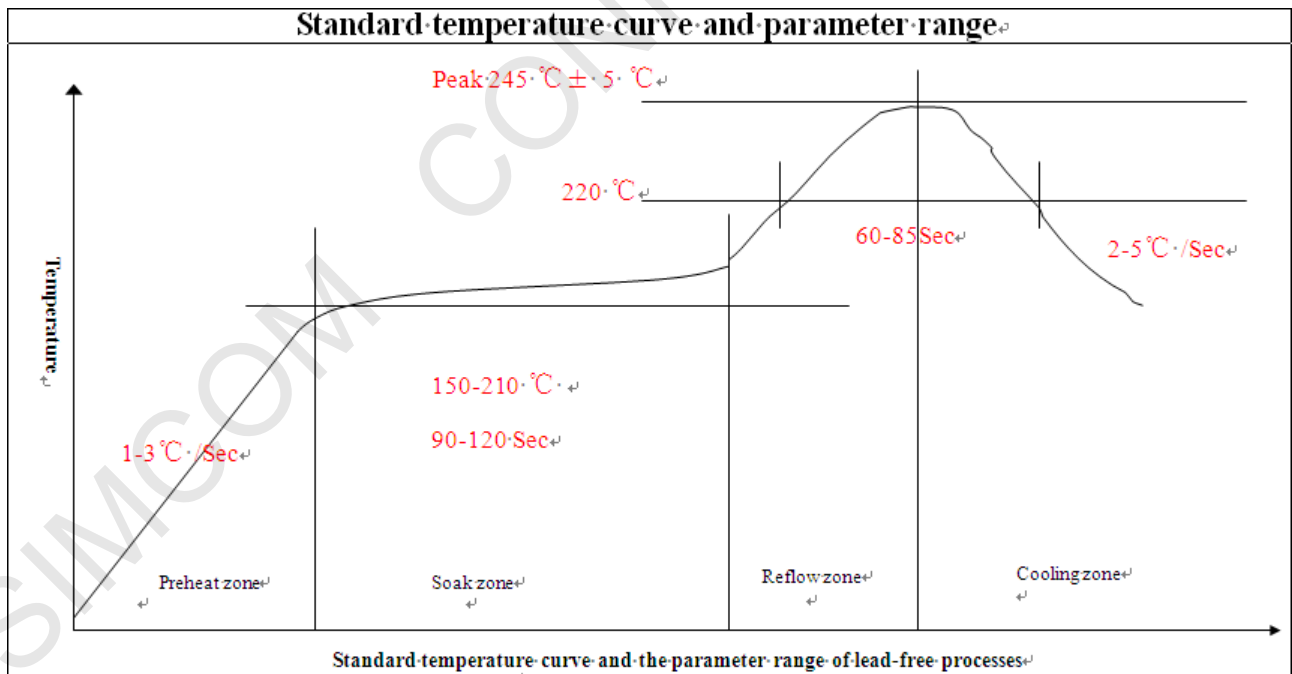## 7.2. Typical Solder Reflow Profile

Figure 52: Typical solder reflow profile of lead-free processes

Note: Please refer to 《Module secondary-SMT-UGD》 for more information about the module shipping and manufacturing.

7.3. The Moisture Sensitivity Level

The moisture sensitivity level of Heracles module is 3. The modules should be mounted within 168 hours after unpacking in the environmental conditions of temperature <30 ℃ and relativ necessary to bake the module if the above conditions are not met:

Table 49: 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
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, it must be reflowed within the time limit specified on the label.

Note: For product handling, storage, processing, IPC / JEDEC J-STD-033 must be followed.

7.4. Baking Requirements

Heracles modules are vacuum packaged, and guaranteed for 6 months storage without opening or leakage under the following conditions: the environment temperature is lower than 40 ℃, and the air h

If the condition meets one of the following ones shown below, the modules should be baked sufficiently before re-flow soldering, and the baking condition is shown in below table; otherwise the module will be at the risk of permanent damage during re-flow soldering.

- If the vacuum package is broken or leakage;
- If the vacuum package is opened after 6 months since it's been packed;
- If the vacuum package is opened within 6 months but out of its Floor Life at factory ambient ≦30℃/60% RH or as stated

Table 50: Baking requirements

Baking temperature	Moisture	Time
40 ℃ ±5℃	<5%	192 hours
120 ℃ ±5℃	<5%	6 hours

Note: Care should be taken if that plastic tray is not heat-resistant, the modules should be taken out for preheating, otherwise the tray may be damaged by high-temperature heating.

8. Packaging

Heracles supports two kinds of packaging, standard packaging and sample packaging.

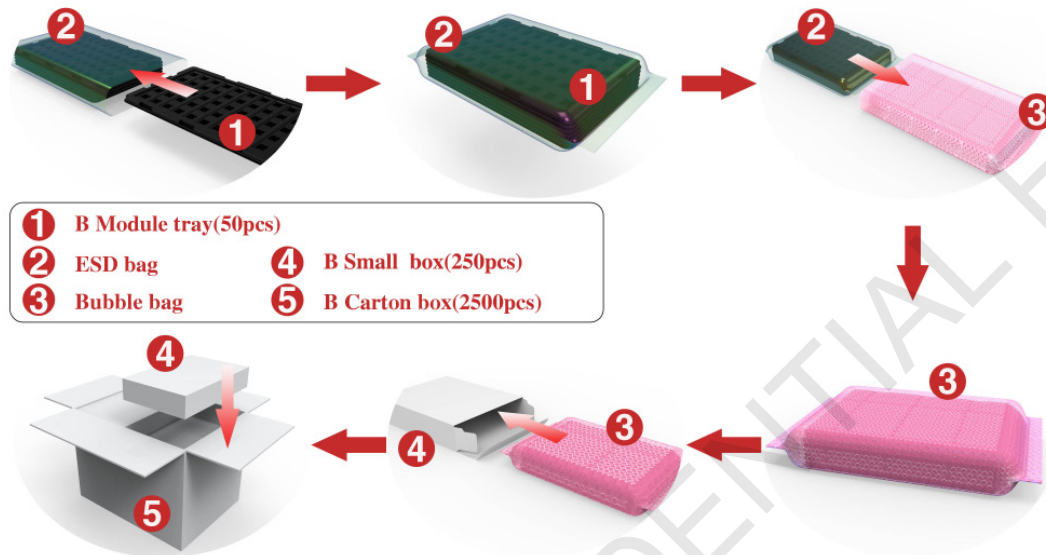## 8.1. Standard Packaging

Heracles module support tray packaging.

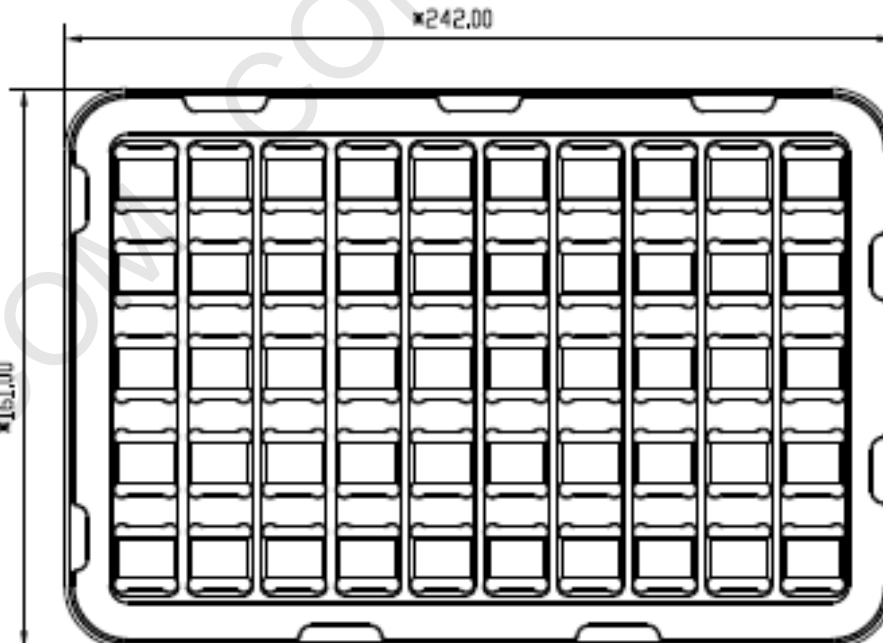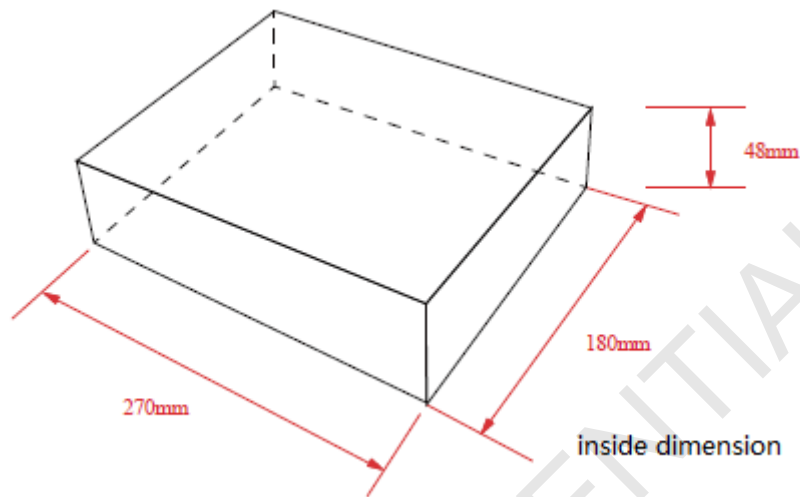**Figure 53: Standard Packaging introduction**

Figure 54: Standard Packaging Module tray drawing
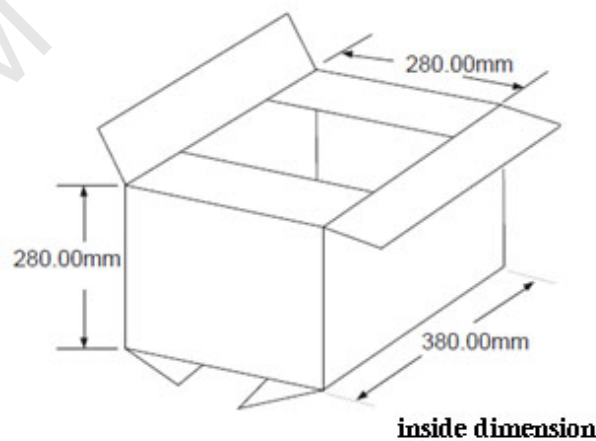
Table 51: Standard Packaging Tray size

Length（±3mm）	Width（±3mm）	Number
242.0	161.0	50

Figure 55: Standard Packaging Small carton drawing

Table 52: Standard Packaging Small Carton size

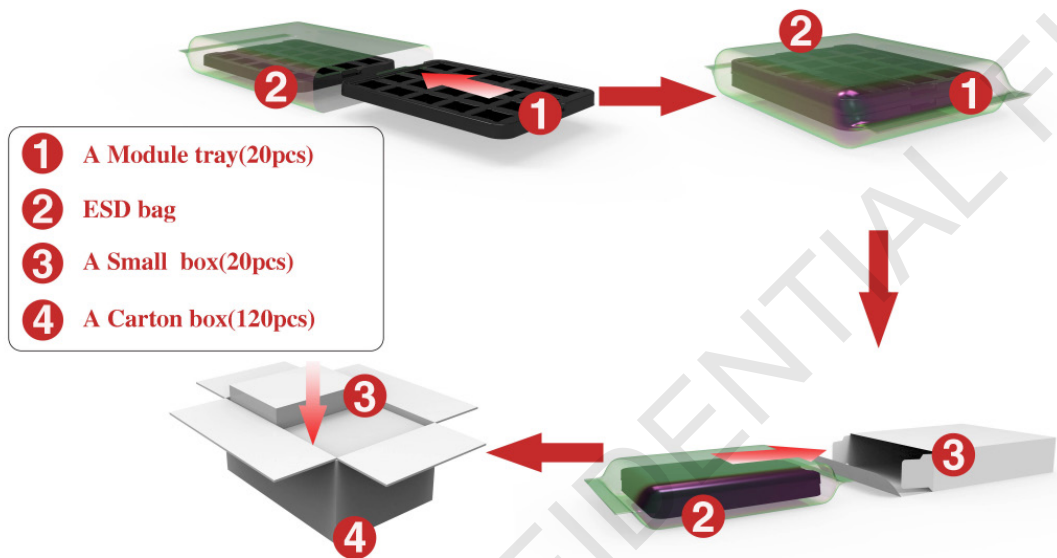| Length（±10mm）	Width（±10mm）	Height（±10mm）	Number
270	180	48	50*5=250

Figure 56: Standard Packaging Big carton drawing

Table 53: Standard Packaging Big Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Number
380	280	280	250*10=2500

8.2. Sample Packaging

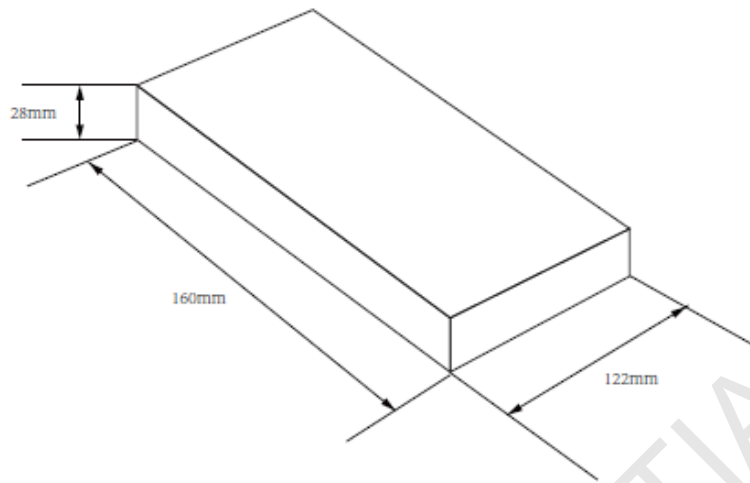Heracles module support tray packaging.

Figure 57: Sample Packaging introduction
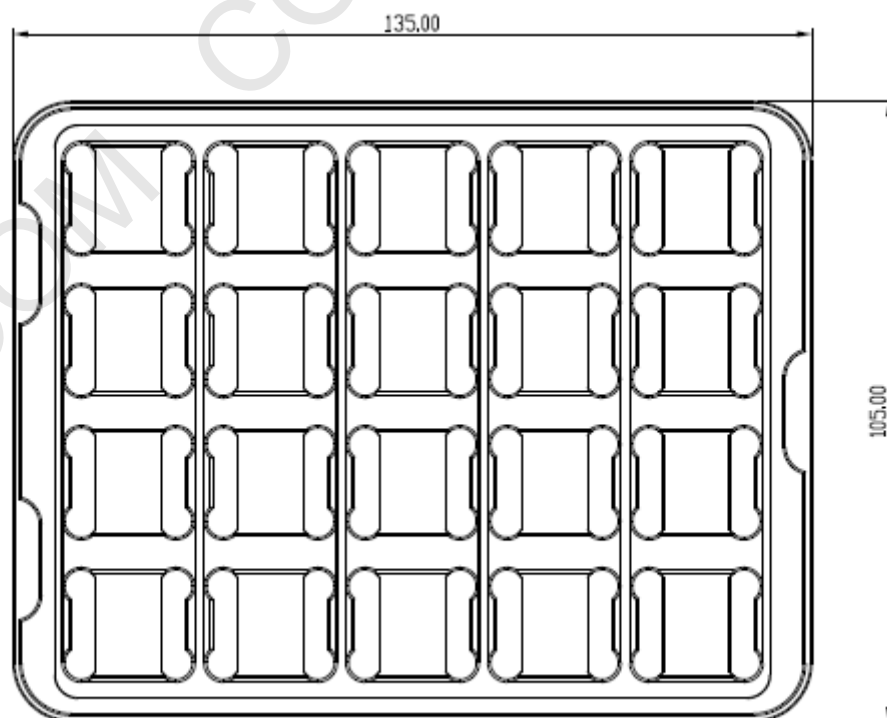
Figure 58: Sample Packaging Module tray drawing

Table 54: Sample Packaging Tray size

Length（±3mm）	Width（±3mm）	Number
135.0	105.0	20

Figure 59: Sample Packaging Small carton drawing

Table 55: Sample Packaging Small Carton size

Length（±8mm）	Width（±8mm）	Height（±8mm）	Number
160	122	28	20
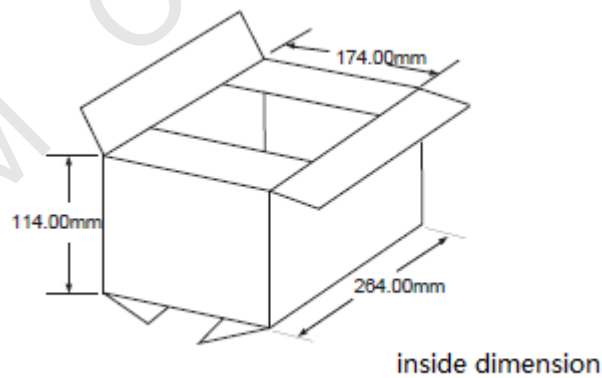
Figure 60: Sample Packaging Big carton drawing

Table 56: Sample Packaging Big Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Number
264	174	114	20*6=120

9. Appendix

I. Related Documents

Table 57: Related documents

SN	Document name	Remark
SN	Document name	
[1]	SIM800 Series AT Command Manual	
[2]	SIM800 Series UART Port Application Note_V1 01.doc	Serial asynchronous automatic dialing and control
[3]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[4]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[5]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[6]	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)
[7]	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
[8]	GSM 11.11	Digital cellular telecommunications system (Phase 2+); Specification of the Subscriber Identity Module – Mobile Equipment (SIM – ME) interface
[9]	GSM 03.38	Digital cellular telecommunications system (Phase 2+); Alphabets and language-specific information
[10]	GSM 11.10	Digital cellular telecommunications system (Phase 2)；Mobile Station (MS) conformance specification；Part 1：Conformance specification
[11]	AN_Serial Port	AN_Serial Port
[12]	Module secondary-SMT-UGD	Module secondary SMT User Guide
[13]	AN_SMT Module_RF_Reference Design_Guide	

II. Terms and Abbreviations

Table 58: Terms and abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
CS	Coding Scheme
CTS	Clear to Send
DTE	Data Terminal Equipment (typically computer, terminal, printer)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FR	Full Rate
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HR	Half Rate
IMEI	International Mobile Equipment Identity
Li-ion	Lithium-Ion
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
MT	Mobile Terminated
PAP	Password Authentication Protocol
PBCCH	Packet Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
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
TE	Terminal Equipment, also referred to as DTE
TX	Transmit Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code

| USSD | Unstructured Supplementary Service Data |

III. Safety Caution

Table 59: 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 to not operate normally for 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. 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 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.
SOS	GSM cellular terminals or mobiles operate over radio frequency signals and cellular networks and cannot be guaranteed to connect in all conditions, for example no mobile fee. While you are in this condition and need emergent help, please remember using 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.

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