Air780E

Hardware Design Manual

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Modify the record:

version number	edit a record	dates	author
V1.0.0	newly built	2022-8-23	Chengong
V1.0.1	Add GPIO multiplexing description	2022-9-8	Chengong
V1.0.2	PIN 8 add CAM_VCC power supply pin	2022-9-2	Chengong
V1.0.3	Add description of GPIO in sleep state	2022-9-23	Chengong
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V1.0.5	Add description of dual SIM switching	2022-10-10	Chengong
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V1.1.9	Modify MAIN_DCD pin Remark description	2023-5-25	Chengong
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directory (on computer hard drive)

1. preface

Air780E is an LTE Cat 1 wireless communication module designed based on the Shiftcore EC618 platform. It supports FDD-LTE/TDD-LTE 4G long-range wireless transmission technology. In addition, the module provides universal interfaces such as USB/UART/I2C to meet the requirements of various applications in the IoT industry.

The following figure shows the functional block diagram of the Air780E module:

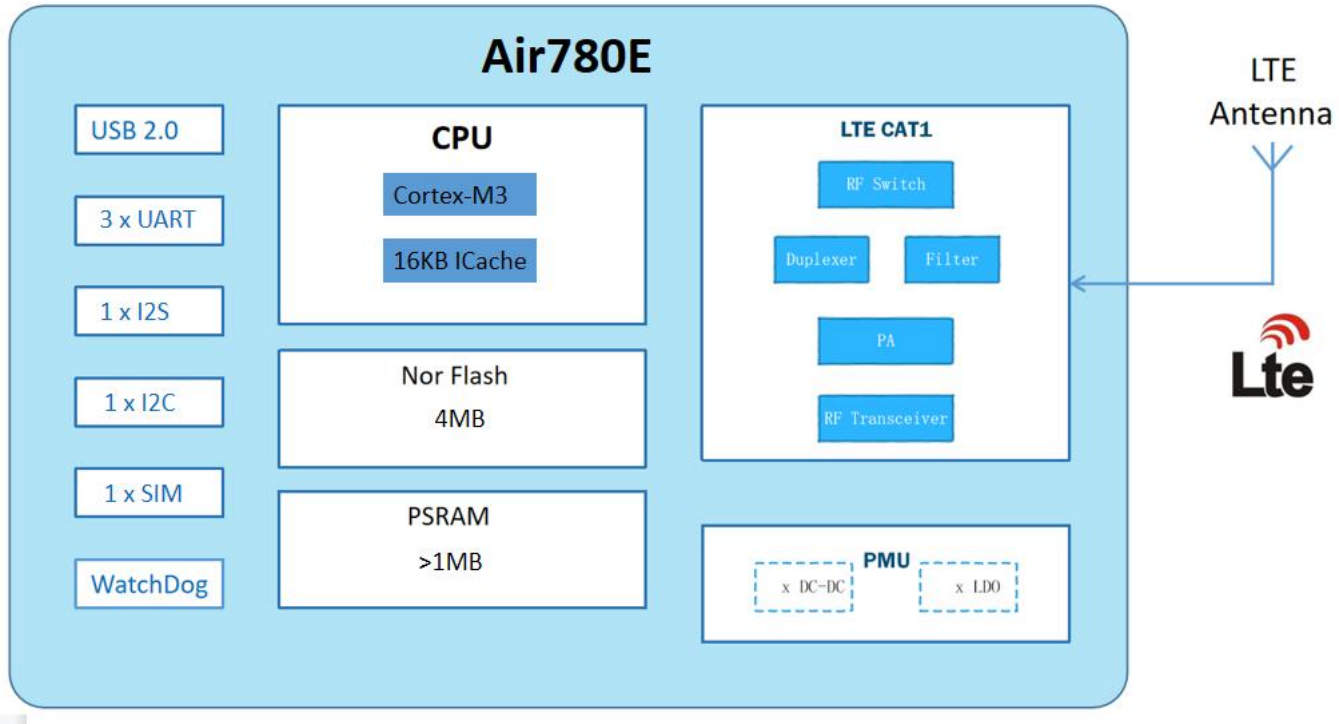


Chart 1 : Functional Block Diagram

2. a roundup

2.1 Model information

Tables 1 : List of Module Models

model number	Air780E	Air780E_3.3V
LTE-FDD	B1/B3/B5/B8	B1/B3/B5/B8
LTE-TDD	b34/b38/b39/b40/b41	b34/b38/b39/b40/b41
IO level	1.8V/3.3V configurable	Fixed 3.3V
Module Size	17.7mm*15.8mm*2.3mm	17.7mm*15.8mm*2.3mm
seal inside	LGA	LGA
note	4G Full Netcom	4G Full Netcom

2.2 Key performance

Tables 2 : Module Main Performance

diagnostic property	instructions
CPU	♦ Cortex M3 @ 204MHz ♦ 16KB ICache
Flash	♦ Nor Flash 4MB
RAM	♦ PSRAM >1MB
Supported Frequency Bands	♦ LTE-FDD: B1/B3/B5/B8 ♦ LTE-TDD: B34/B38/B39/B40/B41
firing power	♦ LTE-FDD: Class3 (23dBm+-2dB) ♦ LTE-TDD: Class3 (23dBm+1/-3dB)
electricity supply	♦ VBAT 3.3V ~ 4.3V, 3.8V typical
LTE Features	♦ Maximum support for non-CA CAT1 ♦ Support 1.4~20MHz RF bandwidth ♦ LTE-FDD: Maximum uplink rate 5Mbps, maximum downlink rate 10Mbps ♦ LTE-TDD: uplink and downlink configuration1 Maximum uplink rate 4Mbps, maximum downlink rate 6Mbps ♦ LTE-TDD: uplink and downlink configurations2 Maximum uplink rate 2Mbps, maximum downlink rate 8Mbps
network protocol characteristic	♦ TCP/UDP/PPP/HTTP/NITZ/NDIS/NTP/HTTPS/MQTT is supported.
USIM card interface	♦ USIM/SIM card support: 1.8V and 3V
USB port	♦ Supports USB 2.0 High speed (Slave mode only), data transfer rate up to 480Mbps. ♦ For AT commands, data transfer, software debugging, software upgrades ♦ USB Virtual Serial Driver: Support USB driver under Windows 7/8.1/10, Linux 2.6.x/3.x/4.1, Android 4.x/5.x/6.x/7.x and other operating systems.

serial port (computing)	MAIN_UART: ♦ Universal serial port for AT commands and data transfer ♦ Maximum baud rate 921600bps, default baud rate adaptive 9600-115200bps ♦ Supports hardware flow control (RTS/CTS) AUX_UART: ♦ Universal Serial Port DBG_UART: ♦ Used to output debugging information
I2C	♦ 1 I2C interface
I2S	♦ 1 digital audio interface ♦ External codec chip available
WatchDog	♦ software watchdog
Antenna Interface	♦ One LTE antenna connector
Temperature range *	♦ Normal operating temperature: -35° C to +75° C ♦ Extreme operating temperature: -40° C to +85° C
RoHS	♦ All devices are fully RoHS compliant
physical property	♦ Size: 17.7mm*15.8mm*2.3mm ♦ Weight: approx. 2.6g
seal inside	♦ 109 pins, see pin diagram for actual available pins

***Note.**

When the module operates in the temperature range of -40° C to -35° C or +75° C to +85° C, the module can work normally, but some of the RF specifications are not guaranteed to meet the 3GPP standard.

3. application interface

The module is available in an LGA package with 109 SMT pad pins. The following sections describe in detail the function of each Air780E interface.

3.1. Pin Description

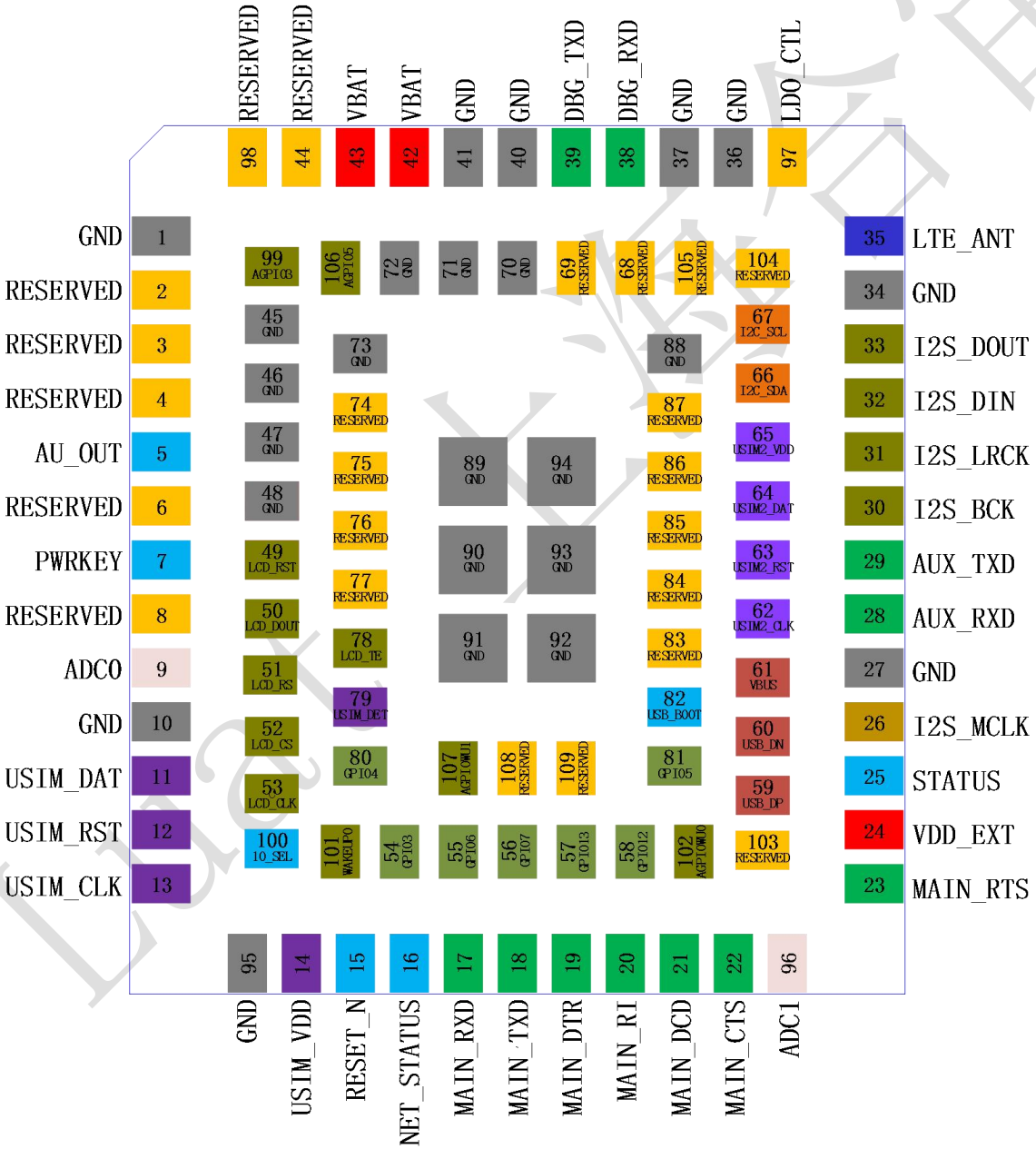


Chart 2 : Air780E Pin Arrangement Diagram (Front View)

Tables 3 : Pin Descriptions

Pin Number	Pin Name	Type	Default Pull	Power Domain	Discription	Remark
1	GND				reference point	
2	RESERVED				Retain pins, dangling	
3	RESERVED				Retain pins, dangling	
4	RESERVED				Retain pins, dangling	
5	AU_OUT	DO	PU	VDD_EXT	Built-in analogue audio signal output	Cannot be used at the same time as the PIN21 MAIN_DCD pin
6	RESERVED				Retain pins, dangling	
7	PWRKEY	DI	PU	VBAT	Module power on/off control pin. internal pull-up to VBAT. If you need to power on, you can pull PWRKEY all the way down to achieve power on.	1. Pull the pin down for more than 1s in the off state and turn on the module. 2. Pull the pin down for more than 1.5s when the module is switched on.
8	RESERVED				Retain pins, dangling	
9	ADC0	AIO		LDOAIO	Analogue-to-digital interface, resolution 12bits, corresponds to module internal AIO3; external DC input range 0-3.4V; conversion time about 200us	If you don't use it, it hangs in the air.
10	GND				reference point	
11	USIM_DAT	IO		USIM_VDD	SIM0 data signal	The module automatically recognises 1.8V or 3V(U) SIM cards.
12	USIM_RST	DO		USIM_VDD	SIM0 Reset signal	
13	USIM_CLK	DO		USIM_VDD	SIM0 Clock signal	
14	USIM_VDD	PO		USIM_VDD	LDO output, 1.2-3.3V adjustable, powers SIM0; Default voltage is 1.8V, IOmax=34mA, default is off after power on.	
15	RESET_N	DI	PU	LDOAON	Module reset input, active-low, no external pull-up required, 1.1V high	If you don't use it, it hangs in the air.
16	NET_STATUS	DO	PD	LDOAON	Network Status Indication	If you don't use it, it hangs in the air.
	GPIO[27] *	IO			General Purpose GPIOs, Sleep Holding	

17	MAIN_RXD	DI	PU	VDD_EXT	Serial port to receive data, sleep state can wake up the module	If you don't use it, it hangs in the air.
	GPIO[18] *	IO			General Purpose GPIOs, shutdown in sleep state	
18	MAIN_TXD	DO	PU	VDD_EXT	Serial port to send data, sleep state can wake up the module	Log messages are output for a short period of time during power-up.
	GPIO[19] *	IO			General Purpose GPIOs	
19	MAIN_DTR	DO	PD	LDOAON	AT firmware function pin, pull high to allow the module to enter hibernation mode; in hibernation mode, pull low to wake up the module	Disable pull-up with VDD_EXT; Fixed level 1.1V (non-adjustable)
	GPIO[22] *	IO			General-purpose GPIOs, which can be held in hibernation.	When configured as a GPIO, the levels are configurable
20	MAIN_RI	DO	PD	LDOAON	Ringer signal to wake up the AP,can be held in sleep state.	If you don't use it, it hangs in the air.
	GPIO[24] *	IO			General-purpose GPIO, can be held in sleep state.	
21	MAIN_DCD	DI	PU	VDD_EXT	UART carrier detection	Cannot be used at the same time as the PIN5 AU_OUT pin
	GPIO[2] *	IO			General Purpose GPIOs, shutdown in sleep state	
22	MAIN_CTS	DO	PU	VDD_EXT	Serial port 1 request to send	If you don't use it, it hangs in the air.
	GPIO[16] *	IO			General Purpose GPIOs, shutdown in sleep state	
23	MAIN_RTS	DI	PU	VDD_EXT	Serial Port 1 Clear Transmit	If you don't use it, it hangs in the air.
	GPIO[17] *	IO			General Purpose GPIOs, shutdown in sleep state	
24	VDD_EXT	PO		VDD_EXT	LDO output. Hardware configurable via PIN100, outputs 3.3V or 1.8V ,default 1,8V, max 200Ma. Shutdown in hibernation state, hibernation state will output high pulses frequently, not to be used for module wake-up pins or serial port pull-ups.	1. Dangling if not in use 2. All IOs in the VDD_EXT voltage domain are powered down and shut down in the sleep state, and periodically output high pulses
25	STATUS	DO	PD	LDOAON	Module operation status indication; AT firmware version outputs a high level after 400ms of power-up, which can be held in sleep state.	If you don't use it, it hangs in the air.
	GPIO[26] *	IO			General Purpose GPIO , hold in sleep state.	

26	I2S_MCLK	IO	PU	VDD_EXT	I2S Reference Clock	
27	GND				reference point	
28	AUX_RXD	DI	PU	VDD_EXT	Auxiliary serial port to receive data	Either one or both of the PIN 51 LCD_RS pins cannot be used at the same time; Unable to wake up the module through the serial port
	GPIO[10] *	IO			General Purpose GPIOs, shutdown in sleep state	
29	AUX_TXD	DO	PU	VDD_EXT	Auxiliary serial port sends data	Either/or with PIN 53 LCD_CLK pin, cannot be used at the same time Unable to wake up the module through the serial port
	GPIO[11] *	IO			General Purpose GPIOs, shutdown in sleep state	
30	I2S_BCK *	DO	PD	VDD_EXT	I2S Clock Output	If you don't use it, it hangs in the air.
	GPIO[29] *	IO			General Purpose GPIOs, shutdown in sleep state	
31	I2S_LRCK *	DO	PD	VDD_EXT	LRCK is "0" to indicate that the left channel data is being transmitted, and "1" to indicate that the right channel data is being transmitted.	If you don't use it, it hangs in the air.
	GPIO[30] *	IO			General Purpose GPIOs, shutdown in sleep state	
32	I2S_DIN *	DI	PD	VDD_EXT	I2S Data Input	If you don't use it, it hangs in the air.
	GPIO[31] *	IO			General Purpose GPIOs, shutdown in sleep state	
33	I2S_DOUT *	DO		VDD_EXT	I2S Data Output	If you don't use it, it hangs in the air.
34	GND				reference point	
35	LTE_ANT				LTE Antenna Interface	Alignment needs to control 50 ohm characteristic impedance
36	GND				reference point	
37	GND				reference point	
38	DBG_RXD	DI	PU	VDD_EXT	Receive data through serial port	
	GPIO[14] *	IO			General Purpose GPIOs, shutdown in sleep state	
39	DBG_TXD	DO	PU	VDD_EXT	Send data through serial port	Debugging information is output for a short time

						during the boot process
	GPIO[15] *	IO			General Purpose GPIOs, shutdown in sleep state	
40	GND				reference point	
41	GND				reference point	
42	VBAT	PI		VBAT	Module main power supply, power supply range 3.3V~4.3V	RF metrics deteriorate at voltages below 3.3V
43	VBAT	PI		VBAT		
44	RESERVED				Retain pins, dangling	
45	GND				reference point	
46	GND				reference point	
47	GND				reference point	
48	GND				reference point	
49	LCD_RST	DO	PD	VDD_EXT	SPI LCD reset signal	
	GPIO[1] *	IO			General Purpose GPIOs, shutdown in sleep state	
50	LCD_DOUT	DO	PU	VDD_EXT	SPI LCD data signal	
	GPIO[9] *	IO			General Purpose GPIOs, shutdown in sleep state	
51	LCD_RS	DO	PU	VDD_EXT	SPI LCD Data Command Selection	If you don't use it, it hangs in the air.
	GPIO[10] *	IO			General Purpose GPIOs, shutdown in sleep state	
52	LCD_CS	DO	PU	VDD_EXT	SPI LCD Slice Selection	If you don't use it, it hangs in the air.
	GPIO[8] *	IO			General Purpose GPIOs, shutdown in sleep state	
53	LCD_CLK	DO	PU	VDD_EXT	SPI LCD clock signal	If you don't use it, it hangs in the air.
	GPIO[11] *	IO			General Purpose GPIOs, shutdown in sleep state	
54	GPIO[3] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	If you don't use it, it hangs in the air.
55	GPIO[6] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	Either/or with PIN 64 USIM2_DAT pin, cannot be used at the same time
56	GPIO[7] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	If you don't use it, it hangs in the air.
57	GPIO[13] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	If you don't use it, it hangs in the air.
58	GPIO[12] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	If you don't use it, it hangs in the air.
59	USB_DP	IO			USB differential signal positive	USB2.0 High speed, 90 ohm

60	USB_DM	IO			USB Differential Signal Negative	differential impedance for alignment control, for module upgrades, recommended to reserve a test point.
61	VBUS	DI	DOWN	LDOAON	USB Plug-in Wake-up , high effective, and hold in hibernation.	Internal Resistor Voltage Divider
62	USIM2_CLK			USIM_VDD	USIM2 Clock	1, When using USIM2, PIN99 AGPIO3 can only be used as an external IO pull-up, and cannot be used for other functions. 2, When using USIM2, the camera port cannot be used and PIN80,PIN81,PIN55 must be left empty.
63	USIM2_RST			USIM_VDD	USIM2 reset, pull-up to USIM_VDD required for use	
64	USIM2_DAT			USIM_VDD	USIM2 data, to be pulled up to USIM_VDD when used	
65	USIM2_VDD	PO		USIM_VDD	LDO output, 1.2-3.3V adjustable, powers SIM0; Default voltage is 1.8V, IOmax=34mA, default is off after power on.	
66	I2C_SDA *	IO		VDD_EXT	I2C Data Signals	When used for I2C, external pull-up is required; AT instruction set does not support I2C and GPIO operation at the moment, if not used, it will be left blank.
67	I2C_SCL *	IO		VDD_EXT	I2C Clock Signal	
68	RESERVED				Retain pins, dangling	
69	RESERVED				Retain pins, dangling	
70	GND				reference point	
71	GND				reference point	
72	GND				reference point	
73	GND				reference point	
74	RESERVED				Retain pins, dangling	
75	RESERVED				Retain pins, dangling	
76	RESERVED				Retain pins, dangling	
77	RESERVED				Retain pins, dangling	
78	LCD_TE			LDOAON	SPI LCD selection, currently not supported	
	GPIO[28] *	IO	PU		General-purpose GPIOs, which can be held in	

					hibernation.	
79	USIM_DET	IO	DOWN	LDOAON	SIM card insertion detection, only for SIM1 interface insertion detection. Upper and lower edge level trigger interrupt. Fixed level 1.1V	Disable VDD_EXT pull-up in hibernation state
	WAKEUP2 *	DI			External input interrupt, fixed level 1.1V (can wake up the module in deep sleep mode)	Disable VDD_EXT pull-up in hibernation state
80	GPIO[4] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	One or the other of PIN63 SIM2_RST, cannot be used at the same time.
81	GPIO[5] *	IO	PU	VDD_EXT	General Purpose GPIOs, shutdown in sleep state	Either one of PIN62 SIM2_CLK or PIN62 SIM2_CLK, cannot be used at the same time.
82	USB_BOOT	DI	PD	LDOAON	Pull up to VDD_EXT before powering on, the module will force into USB download mode.	It is recommended to reserve a test point for upgrading the firmware.
83	RESERVED				Retain pins and leave them dangling	
84	RESERVED				Retain pins and leave them dangling	
85	RESERVED				Retain pins and leave them dangling	
86	RESERVED				Retain pins and leave them dangling	
87	RESERVED				Pins retained and left hanging X`	
88	GND				reference point	
89	GND				reference point	
90	GND				reference point	
91	GND				reference point	
92	GND				reference point	
93	GND				reference point	
94	GND				reference point	
95	GND				reference point	
96	ADC1	AIO		LDOAIO	Analogue-to-digital interface, resolution 12bits, corresponds to module internal AIO4; external DC input range 0-3.4V; conversion time about 200us	If you don't use it, it hangs in the air.
97	LDO_CTL	IO	PU	VDD_EXT	External audio CODEC supply LDO control pin	
	GPIO[12] *				General Purpose GPIOs, shutdown in sleep state	
98	RESERVED				Retain pins, dangling	

99	AGPIO3 *	IO	PD	LDOAON	Hibernation can be maintained.	When using the USIM2 function, AGPIO3 can only be used as an external IO pull-up, and cannot be used for other functions.
	GPIO23 *	IO			General Purpose GPIO , hold in sleep state.	
100	IO_1833_SEL				VDD_EXT voltage selection pin; 1.8V for suspended; 3.3V for 0 ohm ground. (This pin affects the level of all IO ports)	
101	WAKEUP0 *	AI	PD	LDOAON	External input interrupt, fixed level 1.1V (can wake up the module in deep sleep mode)	Disable VDD_EXT pull-up in hibernation state
102	AGPIOWU0 *	AI	PD	LDOAON	External input interrupt, fixed level 1.1V (can wake up the module in deep sleep mode)	Disable VDD_EXT pull-up in hibernation state
	GPIO[20] *	DO			General-purpose GPIO, can be held in sleep state.	
103	RESERVED				Retain pins, dangling	
104	RESERVED				Retain pins, dangling	
105	RESERVED				Retain pins, dangling	
106	AGPIO5 *	IO	PD	LDOAON	General-purpose GPIO, can be held in sleep state.	
	GPIO[25] *				General-purpose GPIO, can be held in sleep state.	
107	AGPIOWU1 *	IO	PD	LDOAON	General-purpose GPIO, can be held in sleep state.	
	GPIO[21] *				General-purpose GPIO, can be held in sleep state.	
108	RESERVED				Retain pins and leave them dangling	
109	RESERVED				Retain pins, dangling	

***Note.**

1. AT instruction set does not support GPIO and special exceptions for the time being, specifically labelled as the pins with "*" in the above table.

2. PIN5 built-in analogue audio function is only supported by the latest Air780E version, please consult the official customer service or sales staff.

3. Secondary development of GPIO multiplexing function is detailed in "Air780E&Air780EG&Air700E_GPIO_table".

4.LDOAON for the chip internal part of the GPIO power supply, the power supply from this power supply IO port sleep state can be maintained.

Tables 4 : IO Parameter Definitions

typology	descriptions
IO	Input/Output
DI	Digital Input
DO	Digital Output
PI	Power Input
PO	Power Output
AI	Analog Input
AO	Analog Output
OD	Open Drain Output

3.2. operating mode

The following table briefly describes the various operating modes mentioned in the next chapters.

Tables 5 Table 5: Modes of operation

paradigm	descriptions	
proper functioning	ACTIVE	The connection works properly. There is data or voice or SMS interaction. In this mode, the module power consumption depends on the strength of the ambient signal, the dynamic DTX control and the RF operating frequency.
	IDLE	MCU kernel clock off, system interruptions can wake up the module at any time. The module registers on the network with no data, voice and SMS interaction. Entering and exiting IDLE mode is automatically managed by the system.
sleep mode	SLEEP1	In hibernation mode. The peripherals are turned off, most of the IOs are powered down, and only the AGPIO can hold the level, which greatly reduces the power consumption. This mode is accessed by AT+CSCLK=1 or AT+CSCLK=2.
Deep Sleep Mode	SLEEP2	Based on the sleep mode, the SRAM is switched off, leaving only the 64KB SRAM (ASMB) area to store the necessary information. Power consumption is further reduced and the DeepSleep timer can still run in this mode. It can be woken up via the WAKUP pin, but the software needs to be re-initialised. this sleep mode is not supported by the AT version.
Ultra Deep Sleep Mode	HIBERNATE	In addition to the sleep mode, the 64KB SRAM (ASMB) area is turned off to minimise power consumption. The DeepSleep timer can still run in this mode, but the software needs to be re-initialised. It can be woken up via the WAKUP pin, but the software needs to be re-initialised. this sleep mode is not supported by the AT version.
shutdown mode	OFF	In this mode, the PMU stops supplying power to the baseband and RF, the software stops working, the serial port is not available, but the VBAT pin is still powered on.

Attention:

- When the module enters hibernation mode or deep hibernation mode, the VDD_EXT power supply will be powered down, and the GPIOs and serial ports in the corresponding voltage domains (except for MAIN_UART) will be in the state of power-down shutdown, and the IO ports will not be able to respond to interrupts, and will not be able to wake the module to exit the hibernation mode.
- After the module enters the hibernation state, it can only be woken up to exit the hibernation mode by the following pin interrupt.

pin name	serial number	**functionality**	descriptions
PWRKEY	7	power on and off	Trigger interrupt on pull-through low power-on pin

MAIN_TXD/RXD	17,18	primary serial port (computing)	Wake up the module by sending data to the serial port.
MAIN_DTR	19	Module wake-up pin	Pull down to trigger wake up interrupt
USIM_DET	79	SIM card insertion and removal detection	Pull down to trigger wake up interrupt
VBUS	61	USB plug-in wake-up	USB plugged in, or pulled up trigger
WAKEUP0	101	Wake-up from external interrupt	Pull down to trigger wake up interrupt
AGPIOWU0	102	Wake-up from external interrupt	Pull down to trigger wake up interrupt
AGPIOWU1	107	Wake-up from external interrupt	Pull down to trigger wake up interrupt

3.3. power supply

pin name	pin number	descriptions
VBAT	42,43	Module baseband power supply, supply range 3.3V~4.3V

3.3.1. Modular Power Supply Operating Characteristics

Power supply design is an important part of module application design. As LTE RF works with a maximum peak current of up to 1.5A, there will be a continuous operating current of about 700mA at maximum transmit power, the power supply must be able to provide sufficient current, otherwise it may cause the supply voltage to drop or even the module directly power down and restart.

3.3.2. Reduced voltage drop

Module power supply VBAT voltage input range of 3.3V ~ 4.3V, but the module in the RF transmitter usually produces a power supply voltage drop phenomenon in the VBAT power supply, this is due to the power supply or the impedance on the alignment path, generally difficult to avoid. Therefore, special attention should be paid to the module's power supply design, in the VBAT input, it is recommended that a low ESR (ESR = 0.7Ω) of 100uF tantalum capacitors in parallel, as well as 100nF, 33pF, 10pF filter capacitors, the VBAT input reference circuit shown in Figure 4.

It is also recommended that the PCB alignment of the VBAT be as short as possible and wide enough to reduce the equivalent impedance of the VBAT alignment to ensure that there is no large voltage drop under high current at maximum transmit power. It is recommended that the width of the VBAT alignment should be not less than 1mm, and the longer the alignment, the wider the line width.

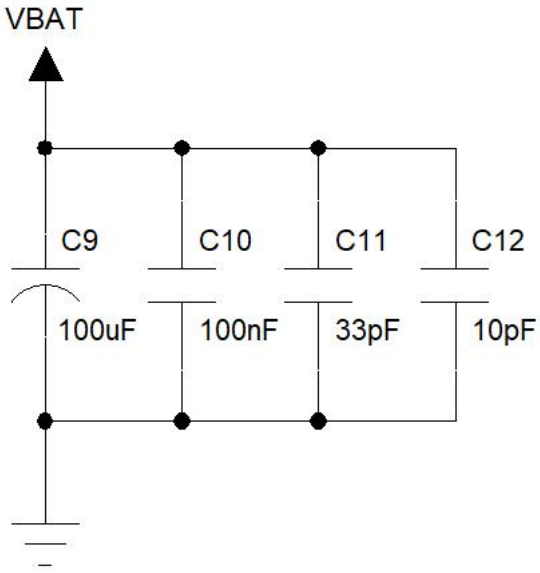


Chart 3 : VBAT Input Reference Circuit

3.3.3. Power Supply Reference Circuit

The power supply design is critical to the power supply of the module, and it is important to select a power supply that is capable of supplying at least 1A of current. If the voltage difference between the input voltage and the module's supply voltage is less than 2V, it is recommended that an LDO be used as the power supply. If the voltage difference between input and output is greater than 2V, a switching power converter is recommended to improve power conversion efficiency.

LDO power supply:

The following figure shows a reference design for a 5V supply, using a Micrel LDO, model MIC29302WU. It has an output voltage of 4.16V and a peak load current of 3A. To ensure the stability of the output power supply, it is recommended that a regulator be reserved at the output and placed close to the VBAT pin of the module. It is recommended to choose a regulator with a reverse breakdown voltage of 5.1V and a power dissipation of 1W or more.

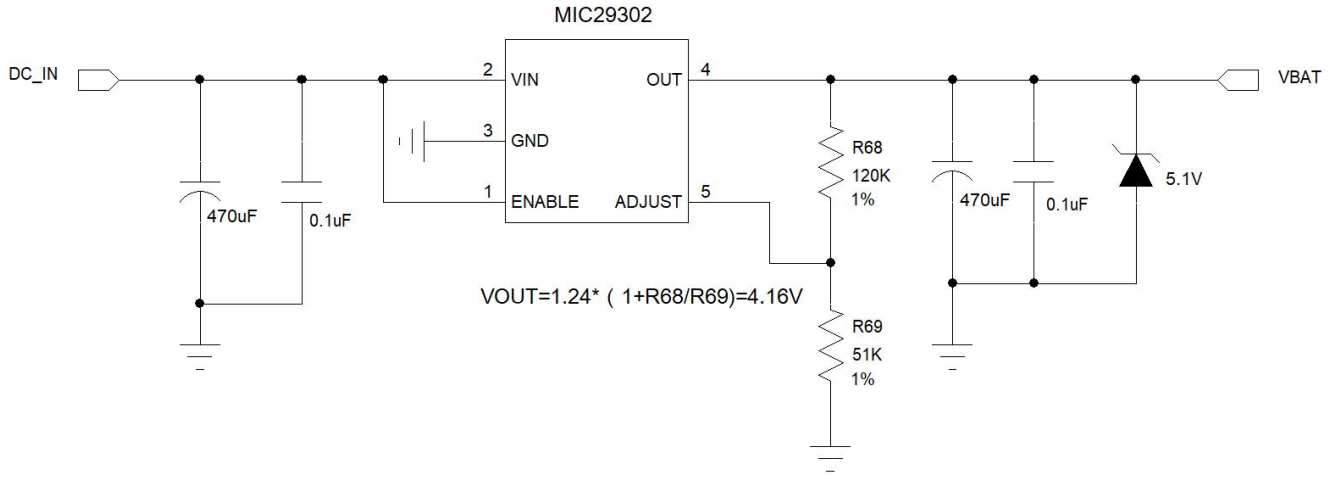


Chart 4 : Power Input Reference Design

DC-DC powered:

The following figure shows the reference design of a DC-DC switching power supply, using the JW5033S switching power supply chip from JWT, which has a maximum output current of 2A and an input voltage range of 3.7V~18V. Note that the selection of C25 should be based on the input voltage to select the appropriate withstand voltage value.

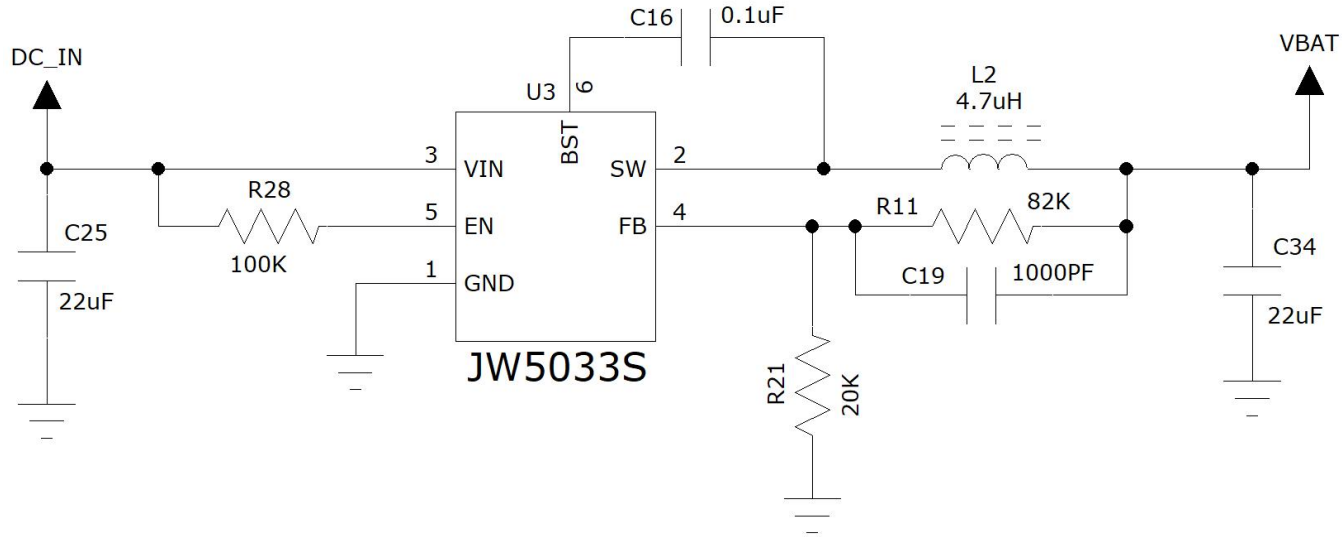


Figure 6: DCDC Power Supply Input Reference Design

3.4. switching mode

3.4.1. press Ctrl-Alt-Delete

pin name	typology	serial number	descriptions
PWRKEY	DI	7	Module power on/off control pin, internal pull-up to VBAT

The Air780E can be triggered to power on after the VBAT is powered up in the following two ways:

1. Key on: PWRKEY pin is connected to ground by touching the key, and the key is pressed for more than 1 second to turn on the power.
2. Power on: short the PWRKEY pin directly to ground and the VBAT will power on.

3.4.1.1 PWRKEY pin on

After VBAT is powered on, the module can be started through the PWRKEY pin, after pulling the PWRKEY pin down for more than 1 second, the module will enter into the power-on process, and the software will detect the voltage of the VBAT pin, if the voltage of the VBAT pin is greater than the power-on voltage (3.3V) set by the software, it will continue the power-on action until the power-on of the system is completed; otherwise, it will stop the execution of power-on action, and the system will be switched off, and the power-on will be completed. The PWRKEY pin can be released after success. You can judge whether the module is powered on or not by checking the level of VDD_EXT pin. It is recommended to use the open set driver circuit to control the PWRKEY pin. The following figure shows the reference circuit:

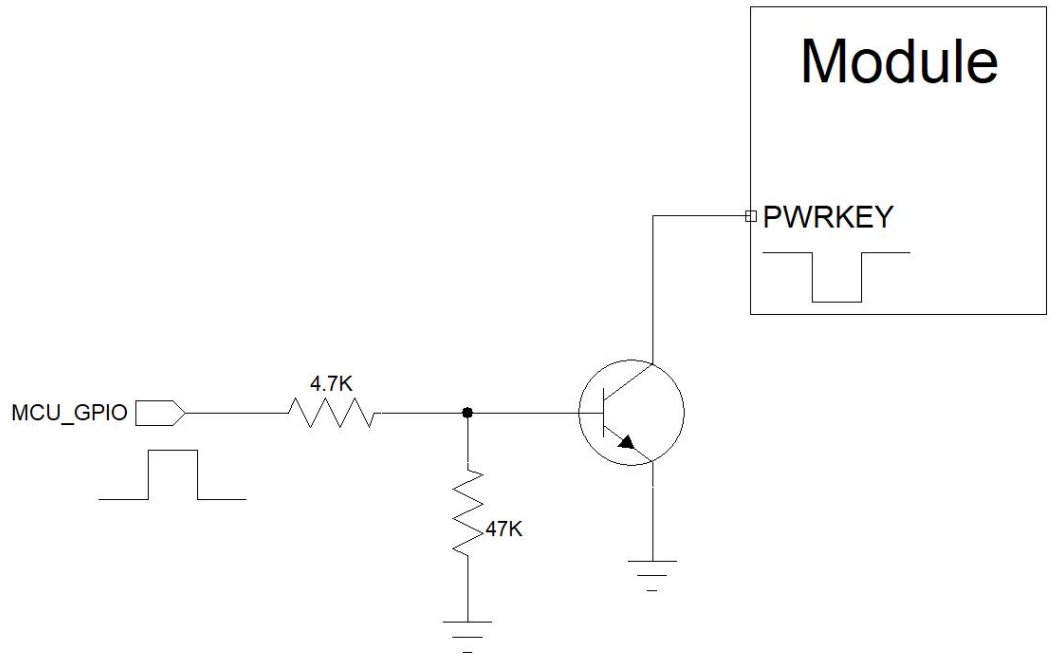


Chart 5 : Open Set Driver Reference Power-Up Circuit

Another way to control the PWRKEY pin is to use a pushbutton switch directly. A TVS tube needs to be placed near the button for ESD protection. The figure below shows the reference circuit:

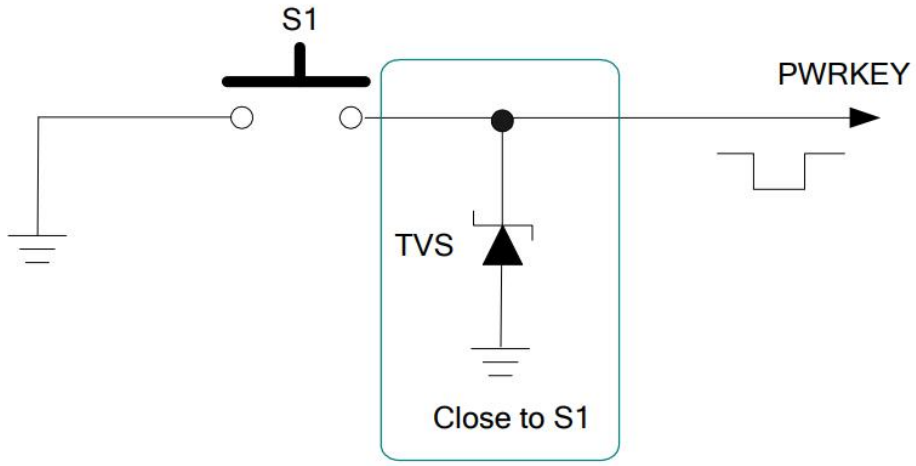


Chart 6 : Key On Reference Circuit

3.4.1.2 Power-up and start-up

The power-on auto power-on function can be achieved by grounding the PWRKEY of the module directly. Note that in power-on mode, the module will not be able to be switched off, as long as the voltage at the VBAT pin is greater than the power-on voltage, even if the software calls the power-off interface, the module will still be switched on again. In addition, in this mode, in order to successfully power on the VBAT pin voltage should still be greater than the power-on voltage set by the software (3.3V), if it does not meet, the module will be shut down, and there will be repeated switching on and off.

The PWRKEY grounded power-on auto-boot method is not recommended for battery-powered application scenarios.

3.4.2. finish shooting a film

The following ways are available to close the module:

- Normal shutdown: shutdown using PWRKEY pin
- Normal shutdown: shutdown by AT command AT+CPOWD
- Low voltage auto shutdown: the module shuts down when it detects low voltage, the threshold value of low voltage can be set by AT instruction AT+CBC;

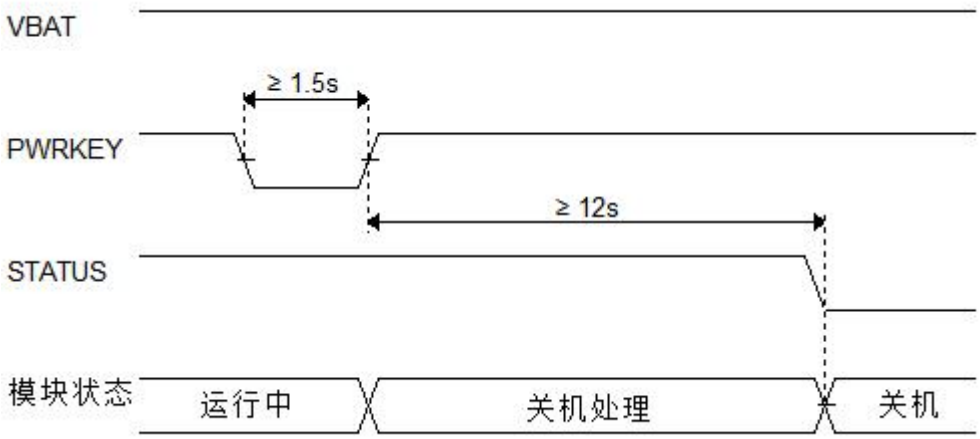
3.4.2.1 PWRKEY pin shutdown

The module performs a shutdown action when the PWRKEY pin is pulled low for more than 1.5s.

During the shutdown process, the module needs to log out of the network, the logout time is related to the current network status, which has been measured to take about 2s~12s, so it is recommended to extend the 12s

before powering off or restarting to ensure that the software saves the important data before completely powering off.

The timing diagram is shown below:



3.4.2.2 Low voltage auto shutdown

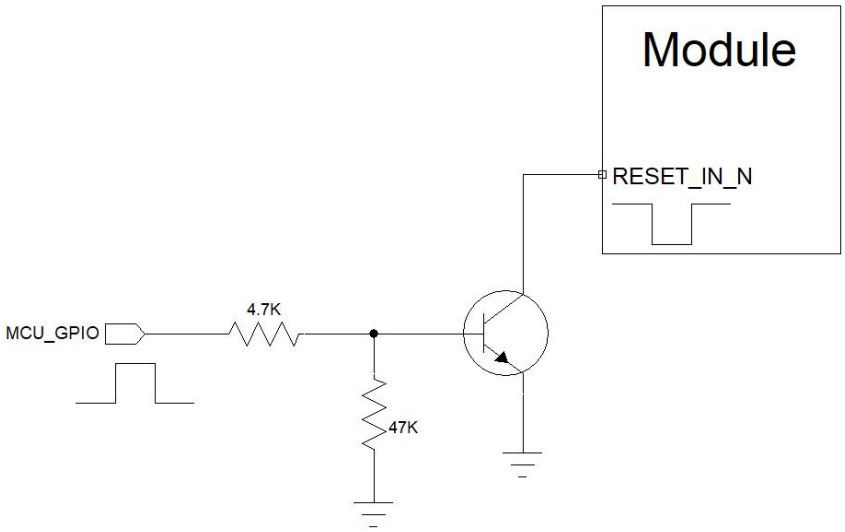
When the voltage of VBAT pin is lower than the shutdown voltage set by the software (default setting 3.3V), the software will perform shutdown action to shut down the module in order to prevent all kinds of abnormality under the operation of low-voltage state.

3.4.3 Reset

pin name	typology	serial number	voltage domain	descriptions
RESET_N	DI	15	-	Module reset input, active low; no external pull-up required

The RESET_N pin can be used to reset the module. Pulling down the RESET_N pin for more than 100ms can reset the module. The RESET_N signal is sensitive to interference, so it is recommended that the wiring on the module interface board be as short as possible and be ground-protected.

Reference Circuit:



Attention:

1. The reset function is recommended for use only after AT+CPOWD and PWRKEY shutdown failures.

2. After the RESET_N reset pin is pulled low and released, the module will be in hardware shutdown state, if you want to restart the function, you need to pull down POWERKEY shutdown again after RESET_N reset to perform the power-on action.

3.5. serial port (computing)

The module provides three general-purpose asynchronous transceivers: MAIN_UART, AUX_UART, and DBG_UART for the main serial port.

3.5.1. MAIN_UART

Tables 6 : MAIN_UART Pin Definitions

pin name	typology	serial num	voltage domain	descriptions
MAIN _TXD	DO	18	VDD_EXT	MAIN_UART Send data
MAIN _RXD	DI	17	VDD_EXT	MAIN_UART Receive data
MAIN _CTS	DO	22	VDD_EXT	Flow control pin, MAIN_UART Request to send data

MAIN _RTS	DI	23	VDD_EXT	Flow control pin, MAIN_UART Clear Transmit

For AT development mode, 3.5.1. MAIN_UART is used to communicate AT commands, MAIN_UART supports fixed baud rate, not adaptive baud rate.

By default, the hardware flow control of the module is turned off. When the client needs hardware flow control, pins **RTS,CTS** must be connected to the client, **AT** command **"AT+IFC=2,2"** can be used to turn on the hardware flow control, **AT** command **"AT+IFC=0,0"** can be used to turn off the flow control. Please refer to "AirM2M Wireless Module AT Command Manual" for details.

MAIN_UART Function held in sleep state to wake up the module

The features of MAIN_UART are as follows:

- Includes data lines TXD and RXD, and hardware flow control lines RTS and CTS.
- 8 data bits, no parity, one stop bit.
- Hardware flow control is turned off by default.
- Used for AT command transmission, digital transmission, etc.
- Support baud rate as follows:
  600,1200,2400,4800,14400,9600,19200,38400,57600,115200,230400,460800,921600bps

Attention:

MAIN_UART outputs a fixed debug message for a short period of time during power-up.

3.5.2. AUX_UART

Tables 7 : AUX_UART Pin Definitions

pin name	typology	serial num	voltage domain	descriptions
AUX_TXD	DO	29	VDD_EXT	AUX_UART Send data
AUX_RXD	DI	28	VDD_EXT	AUX_UART Receive data

AUX_UART is an auxiliary serial port that does not support AT command interaction and is used for certain peripheral communications such as docking GNSS.

The AUX_UART shuts down when it sleeps and cannot be woken up by sending data to the AUX_UART.

3.5.3. DBG_UART

pin name	typology	serial numb	voltage domain	descriptions
DBG_TXD	DO	39	VDD_EXT	Debugging the serial port, outputting AP log.

DBG_RXD	DI	38	VDD_EXT	Debug serial port to receive debug commands

DBG_UART is used to output AP trace during software debugging, and it is recommended to reserve a test point.

DBG_UART outputs a fixed debug message for a short time during power-up.

3.5.4. Serial Connection Method

Serial port connection is more flexible, the following are three commonly used connection methods.

Please refer to the following connection method for 3-wire serial port:

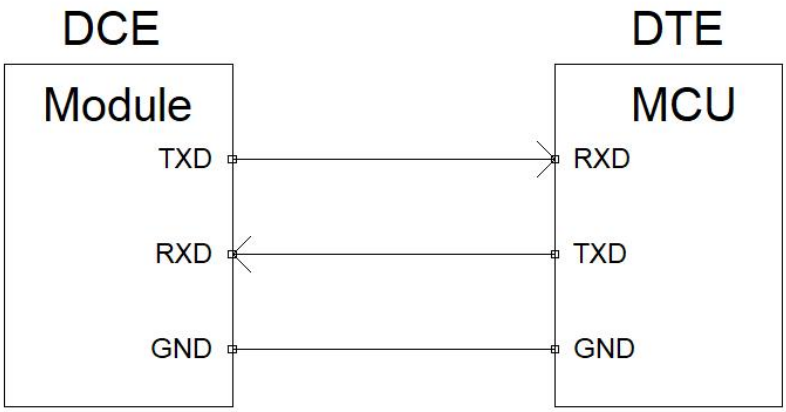


Chart 7 : Diagram of the three-wire connection of the serial port

For serial port connection with flow control, please refer to the following circuit connection. This connection can improve the reliability of large data volume transmission and prevent data loss.

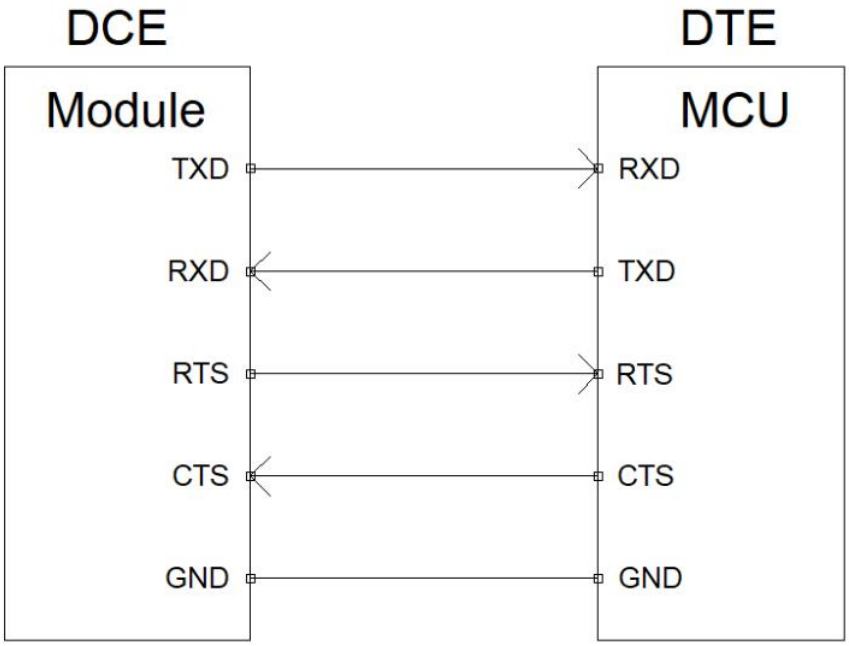
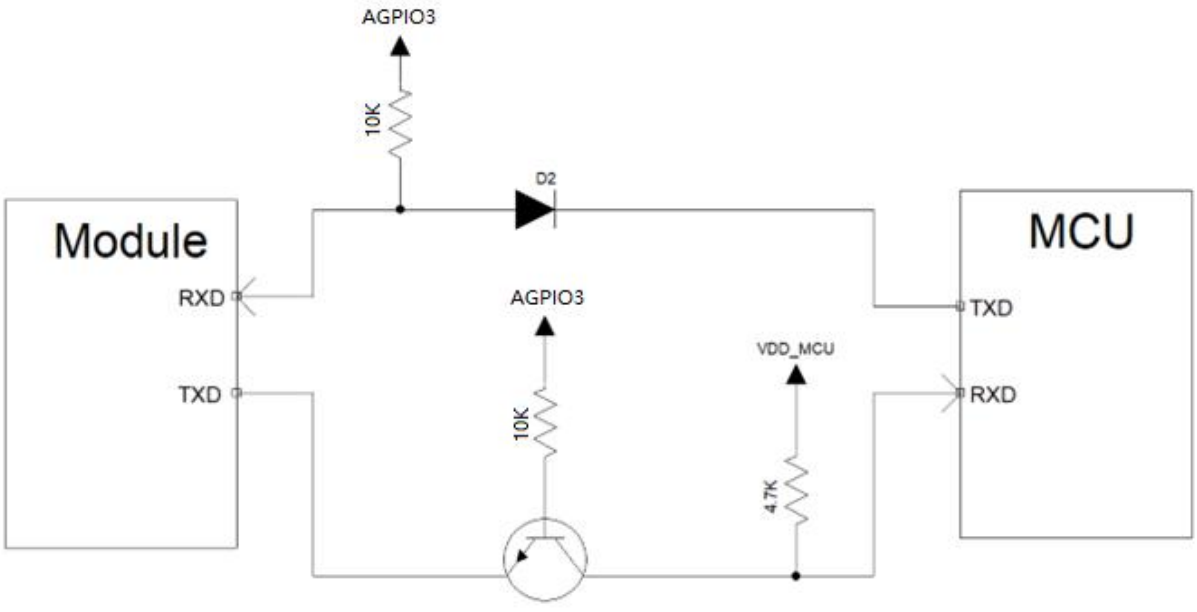


Chart 8 : Diagram of serial port connection with flow control

3.5.5. Serial Voltage Conversion

Air780E module serial port level of 1.8V or 3.3V, through the PIN100 IO_SEL configuration of the IO port level, to meet most of the peripherals, the master of the serial port direct needs, but if you want to communicate with 5V or more MCU or other serial port peripherals, it is necessary to add a level conversion circuit:

The level shifting reference circuit is as follows:



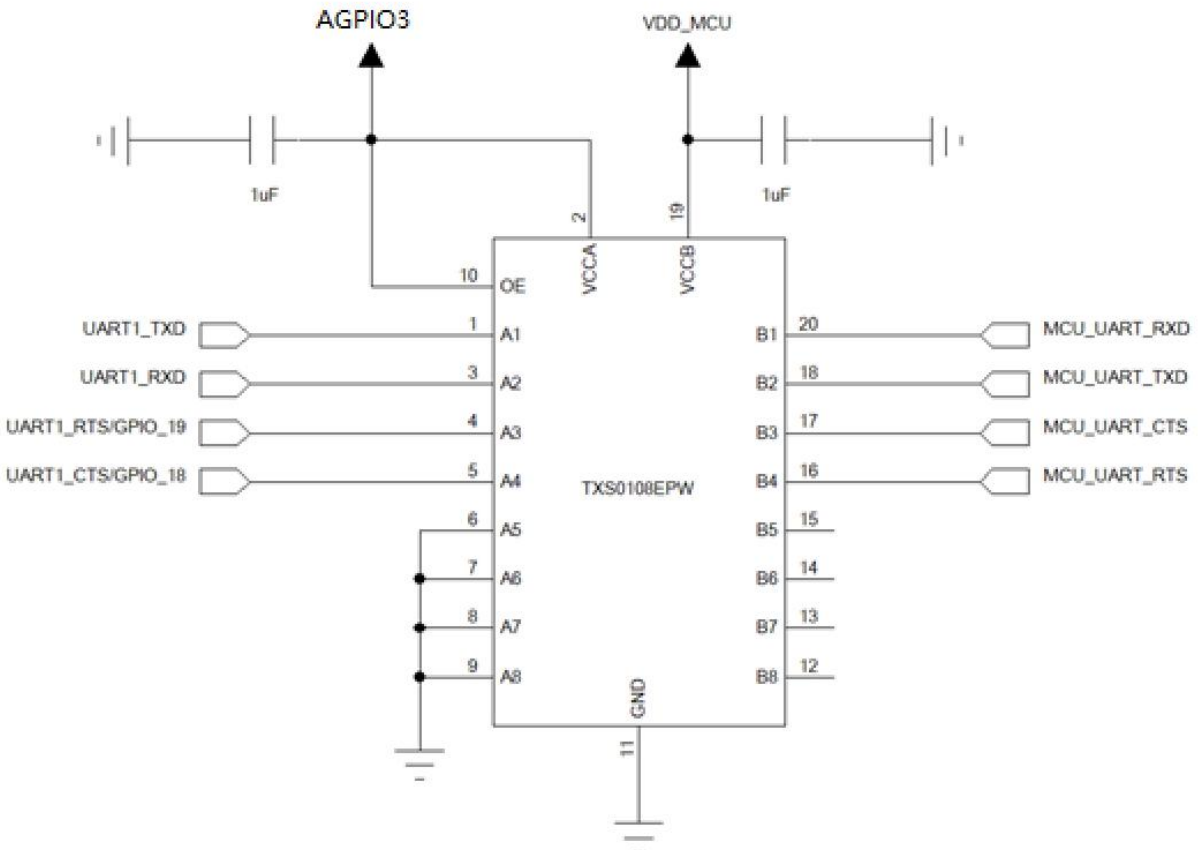
take note of

- This level shifter circuit is not suitable for applications with baud rates higher than 460800 bps.
- Since VDD_EXT will be powered down in hibernation state, if VDD_EXT is used for serial level conversion pull-up in application scenarios where hibernation is required, it will result in a situation where the module cannot hibernate. Therefore, it is recommended to use AGPIO3 for pull-ups in scenarios where hibernation is required.
- D2 A Schottky diode with a low on-state voltage drop must be used.

Recommended models for Schottky diodes and NPN transistors are listed below:

Material Name	model number	company	descriptions
Schottky diode	RB521S-30	Jiangsu Changdian	Schottky Diode;30V;200mA;SOD523;1.6*0.8*0.6mm
	PSB521S-30	Shanghai WiseCrystal	Schottky Diode;30V;200mA;SOD523;1.6*0.8*0.6mm
	LRB521S-30T1G	LRC	Schottky Diode;30V;200mA;SOD523;1.6*0.8*0.6mm
	PSBD521S-30	Prisemi	Schottky Diode;30V;200mA;SOD523;1.6*0.8*0.6mm
NPN Triode	MMBT3904	Jiangsu Changdian	Transistor;NPN;40V;200mA;SOT23;1.1mm;ROHS
	MMBT3904	Shanghai WiseCrystal	Transistor;NPN;40V;200mA;SOT23;1.1mm;ROHS
	LMBT3904LT1G	LRC	Transistor;NPN;40V;200mA;SOT23;1.1mm;ROHS

For applications with baud rates higher than 460800bps, voltage conversion can be achieved by adding an external level conversion chip with the following reference circuit:



The level converter chip used in this circuit is TI's TXS0108E, an 8-bit bi-directional voltage level converter for open drain and push-pull applications, with maximum support rate:

Push-Pull: 110Mbps

Open leakage: 1.2Mbps

3.6. USB port

The Air780E's USB is compliant with the USB 2.0 specification and supports high-speed (480Mbps), full-speed (12Mbps) modes and low-speed (1.2Mbps) modes.The USB interface can be used for AT command transfer, data transfer, software debugging, and software upgrades.

Tables 8 : USB Pin Definitions

pin name	typology	serial numbe	descriptions
USB_DP	IO	59	USB differential signal positive, the alignment needs to control 90 ohms differential impedance
USB_DM	IO	60	USB differential signal negative, the alignment needs to control 90 ohms differential impedance
VBUS	DI	61	USB plug-in wake-up, module internal resistor divider. (not required)

The USB interface reference design circuit is as follows:

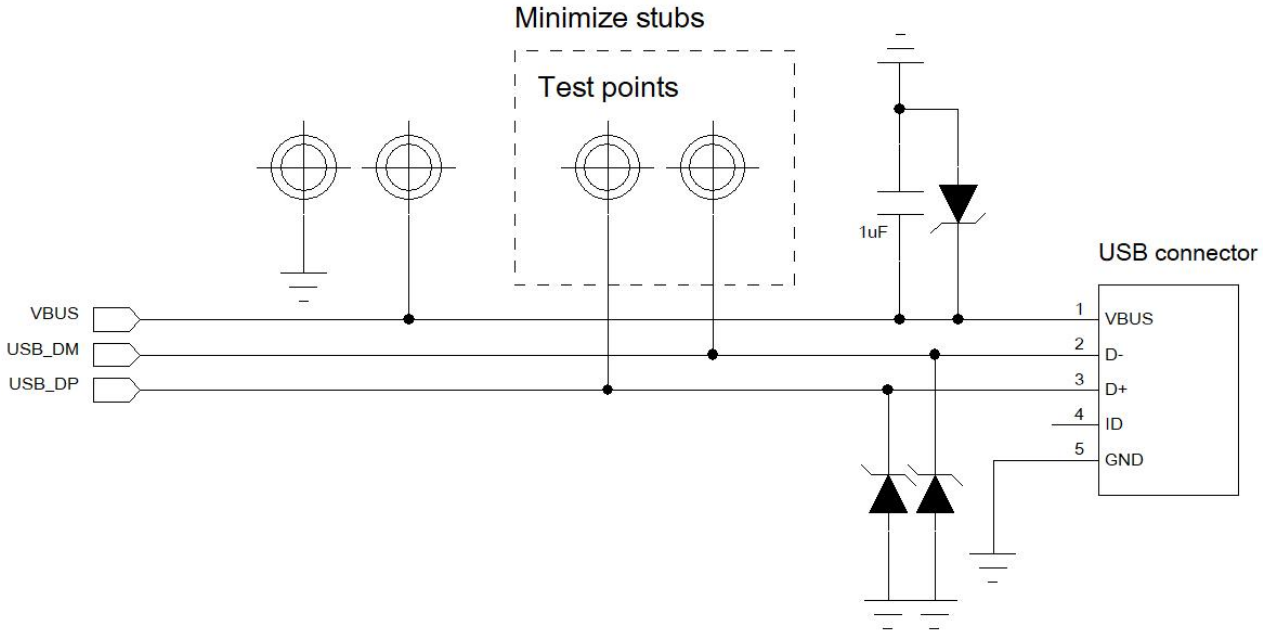


Chart 9 : USB Interface Reference Design

The notes are as follows:

1. USB alignment needs to be strictly controlled by differential lines to be parallel and equal length;
2. The impedance of the USB alignment needs to be controlled to a differential 90 ohms;
3. It is necessary to reduce the stubs of the USB alignment as much as possible to reduce signal reflection; the test point of the USB signal is best placed directly on the alignment to reduce stubs;
4. Minimise the number of cross-holes for USB routing;
5. Near the USB connector or test point to add TVS protection tube, due to the high rate of USB, need to pay attention to the selection of TVS tube, to ensure that the selection of TVS protection tube parasitic capacitance of less than 1pF
6. VBUS as USB insertion wake-up role, and not directly involved in USB insertion detection, non-essential, in the scene does not require USB insertion wake-up can not be connected to the

3.7. USB download mode

pin name	typology	serial num	voltage domain	descriptions
USB_BOOT	DI	82	LDOAON	Pull up to VDD_EXT before power on, the module will be forced into the USB download mode, USB_BOOT must

The Air780E module enters USB download mode:

1. Before booting, pull up USB_BOOT to VDD_EXT

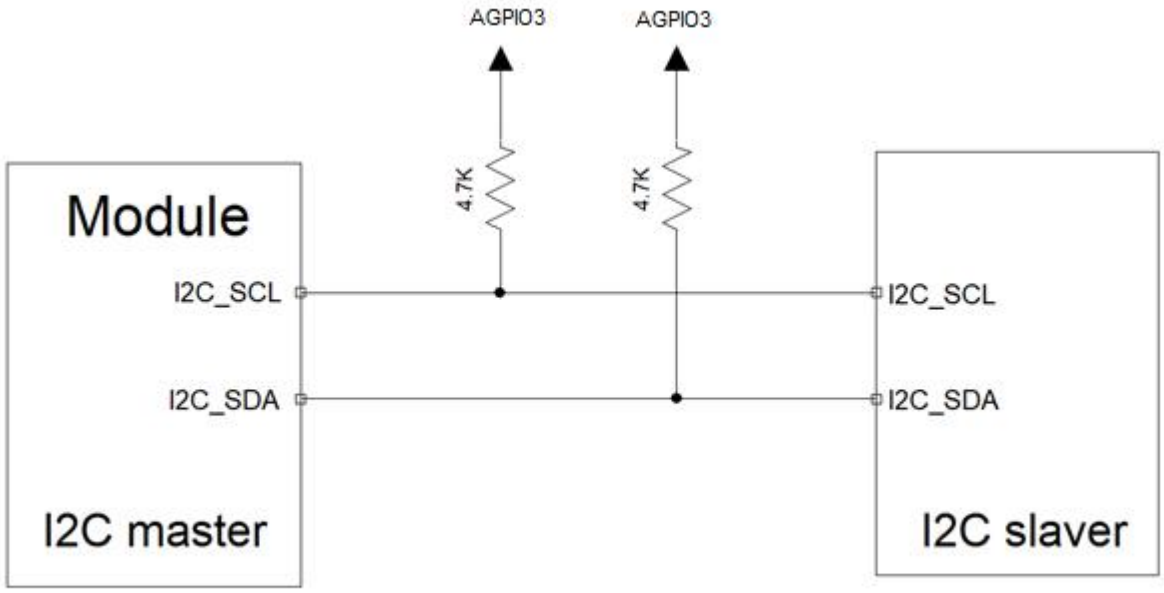
3.8. I2C

pin name	typology	serial num	voltage domain	descriptions
I2C_SCL *	IO	67	VDD_EXT	I2C Clock Signal, pull-up is required when used as I2C.
I2C_SDA *	IO	66	VDD_EXT	I2C data signals, when used as I2C, need to add the pull-up signal

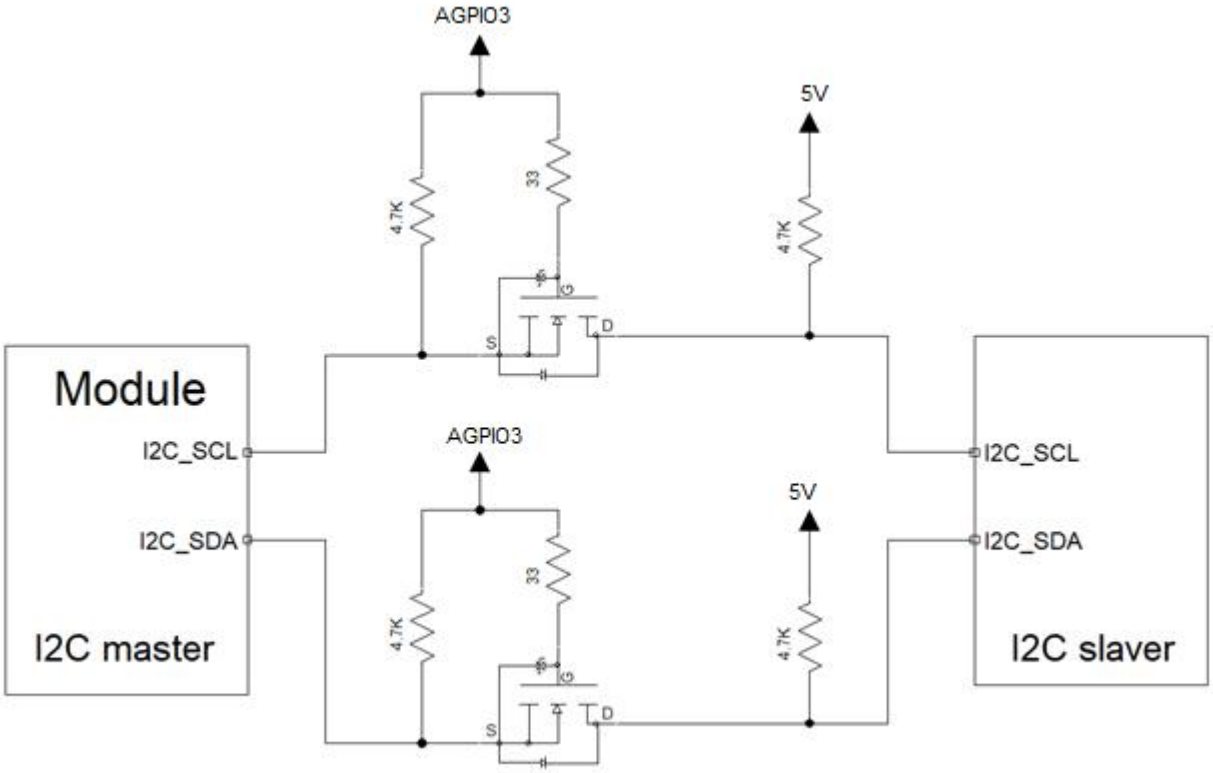
Air780E can support 1 channel I2C interface:

- Compatible with Philips I2C standard protocols
- Fast mode (400Kbps) and Slow mode (100Kbps) are supported.
- Only master mode is supported, not slaver mode.
- Software configurable internal pull-up resistor, 1.8K or 20K.
- Theoretically supports up to 127 slave devices

The reference circuit for I2C is as follows:



The I2C interface voltage of Air780E is 1.8V/3.3V configurable, and the IO port level is configured through PIN100 IO_SEL, which can satisfy the direct needs of most of the peripheral devices, but if you want to communicate with peripheral devices with 5V or above level, it is necessary to add a level conversion circuit:



The above figure is recommended to use AGPIO3 pull-up, in the scenario that does not need the module to enter hibernation or allow hibernation to power down the scenario can also use VDD_EXT pull-up

NMOS tubes for level conversion must be selected with a junction capacitance of less than 50pF, and the recommended models are as follows:

Material Name	model number	company	descriptions
NMOS	BSS138	Jiangsu Changdian	N-Channel,50V,0.22A,SOT-23,ROHS
	BSS138	UMW (Youtai Semiconductor)	N-Channel,50V,0.3A,SOT-23,ROHS

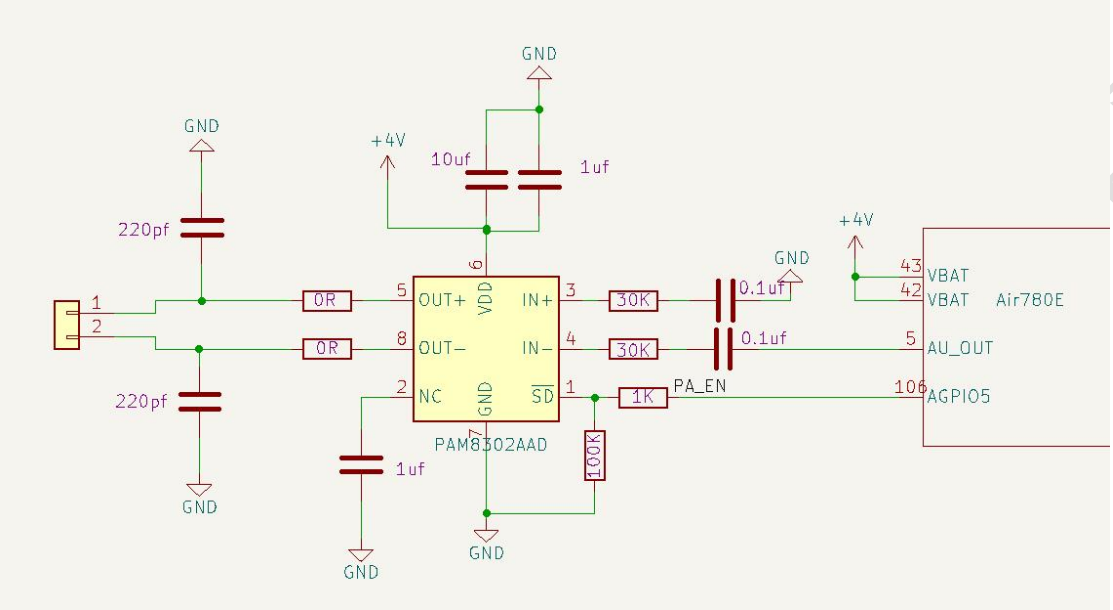
3.9. analogue audio

The built-in analogue voice output function of Air780E module is developed independently by Hezhou based on the EC618 platform of Shiftcore through the simulation of software algorithms, which converts digital voice into analogue voice output, thus realizing the output of sound. This makes up for the lack of built-in audio decoder in EC618 platform. It is mainly used in the development of audio application scenarios, such as cash registers, TTS, and language broadcasting related application scenarios for security.

For detailed design guidance, please refer to the "Air780E Built-in Analogue Voice Function User Guide".

pin name	typology	serial num	voltage domain	descriptions
AU_OUT	DO	5	VDD_EXT	Built-in analogue audio signal output.

The reference circuit is as follows:



Attention:

1. Since PIN5 is a single-ended output, it is easy to be interfered, so the PIN5 alignment should be as short as possible and far away from the interfering signal lines, such as power supply, antenna and so on. And the alignment wrapped in ground protection
2. The audio amplifier PIN3 ground point should be close to the 780E PIN5, and make a differential alignment with PIN5.
3. Audio amplifier outputs PIN8 and PIN5 should be routed differentially, as short as possible, and away from the 4G antenna.
4. PIN106 is the audio amplifier control pin by default, to be used with, it is not recommended to use external master control audio amplifier.
5. The built-in analogue audio function is only supported by the latest Air780E version, please consult the official customer service or sales staff.

3.10. SIM card interface

Air780E supports 2-way SIM card interface, supports ETSI and IMT-2000 card specification, supports 1.8V and 3.0V USIM card. to meet the needs of dual SIM card switching.

3.10.1. SIM interface

The following table describes the pin definitions for the SIM interface.

Tables 9 : SIM Card Interface Pin Definitions

connector	pin name	serial number	descriptions
SIM1	USIM_VDD	14	SIM card power supply, maximum power supply current 10mA. The module can automatically recognise 1.8V or 3V (U) SIM
	USIM_RST	12	SIM card reset signal
	USIM_DAT	11	SIM card data signal
	USIM_CLK	13	SIM card clock signal
	USIM_DET	79	SIM card insertion and removal detection
SIM2	USIM2_VDD	65	SIM2 card power supply, maximum supply current 10mA. The module can automatically recognise 1.8V or 3V (U) SIM cards.
	USIM2_RST	63	SIM2 card reset signal
	USIM2_DAT	64	SIM2 card data signal
	USIM2_CLK	62	SIM2 card clock signal

3.10.2. Dual SIM switching instructions

Air780E supports dual SIM card single standby, only one of the SIM channels can be used at the same time. SIM channel switching can be carried out through the corresponding AT commands: or select the manual switching function, the system will automatically switch according to the external network signal strength (the automatic switching function is usually used in the scenario of using SIM cards of different operators at the same time). For specific commands, please refer to "4G Module AT Command Manual".

Attention:

- The module switch on will detect SIM1 channel by default, and will only go to detect SIM2 channel if SIM1 channel detects that the SIM card is not in position.
- The USIM_DET signal is the SIM card insertion/removal detection pin. The upper and lower edge levels trigger an interrupt, which triggers the system to carry out the card-in-position detection for SIM1 channel. The SIM2 channel does not support SIM card insertion and removal detection.
- For dual-card application scenarios with built-in patch SIM cards, such as webcam (IPC) scenarios, it is recommended that the patch SIM card be placed in the SIM2 channel and the external plug-in SIM card holder in the SIM1 channel to achieve the effect of prioritising the use of the external plug-in SIM card.

3.10.3. SIM interface reference circuit

The following figure shows the reference circuit for the SIM interface, using a 6pin SIM card holder.

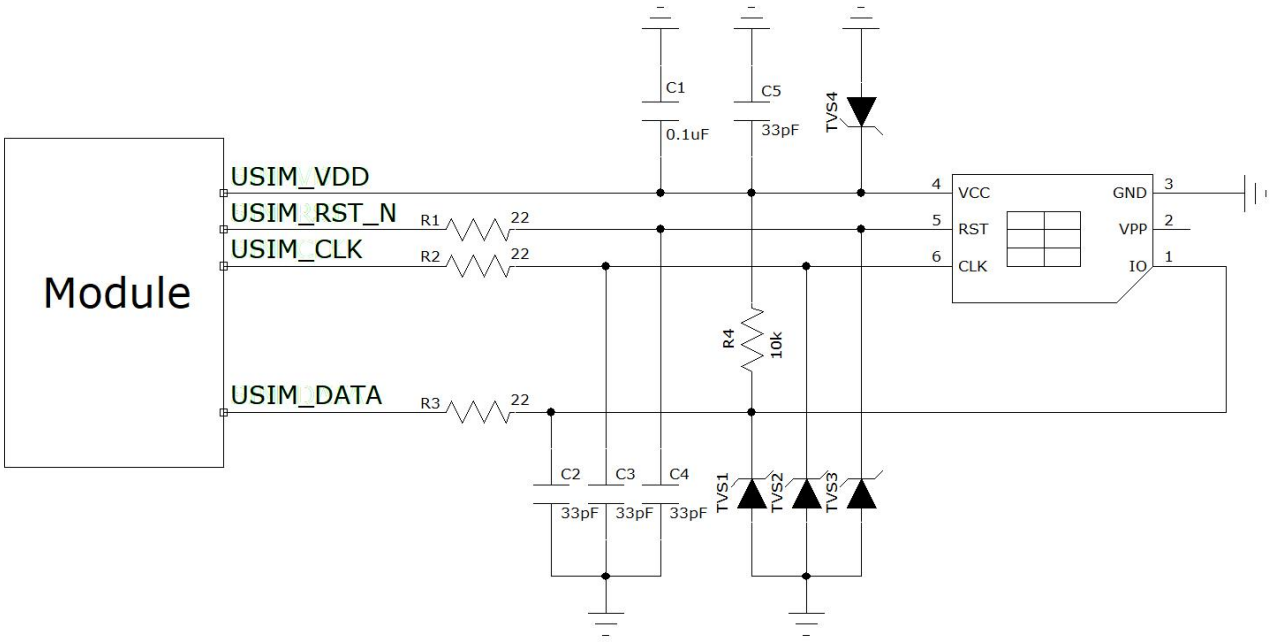


Chart 10 : Reference Circuit Diagram for Using 6pin SIM Card Holder (SIM)

If sim card presence detection is required, the recommended circuit is as follows.

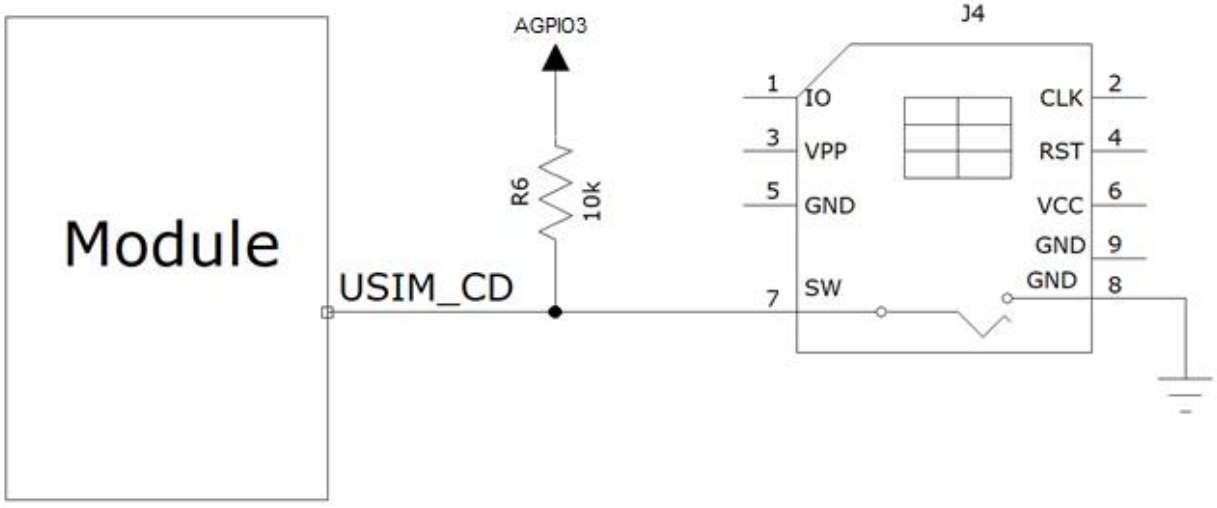


Chart 11 : Reference Circuit Diagram for SIM Card Holder with PIN Detection

In the circuit design of the SIM card interface, the following design principles are recommended in the circuit design in order to ensure good functional performance of the SIM card and not to be damaged:

6. SIM card holder and module distance from the pendulum can not be too far, the closer the better, try to ensure that the SIM card signal cable wiring does not exceed 20cm.
7. SIM card signal wiring is routed away from RF lines and VBAT power lines.
8. To prevent possible crosstalk of the USIM_CLK signal to the USIM_DATA signal, do not route the two too close together and add ground shielding between the two alignments. And ground protection is also required for the USIM_RST_N signal.
9. To ensure good ESD protection, it is recommended to add TVS tubes and place them close to the SIM card holder. The parasitic capacitance of the selected ESD device should not be greater than 50pF. 22 ohm resistors can also be connected in series between the module and the SIM card to suppress stray EMI and enhance ESD protection. the peripheral circuits of the SIM card must be placed as close as possible to the SIM card holder.
10. In scenarios where the module needs to go to sleep SIM_DET prohibits pull-ups with VDD_EXT, otherwise it will cause problems with not being able to sleep. It is recommended to use AGPIO3 pull-up, or use SIM_DET IO internal pull-up

3.11. LDO output

pin name	typology	serial number	descriptions
VDD_EXT	PO	24	LDO output, 3.3V,1.8V adjustable, with PIN 100 external pull-down resistor for hardware configuration, can not be used as wake-up IO shutdown and serial port pull-up.

Attention:

- VDD_EXT serves as the internal power supply for most of the IOs and is powered down and turned off when the module goes to sleep to reduce power consumption.
- VDD_EXT will do network interaction to maintain network registration state with frequent wake-ups of the module bottom layer during the module sleep period. This objectively causes VDD_EXT to output high pulses with varying periods during the module hibernation period. If VDD_EXT is used for certain IOs such as wake-up IO pins or MAIN_UART pull-ups, frequent triggering of IO interrupts will cause the module to fail to go into hibernation.
- In scenarios where hibernation is required you can use AGPIO3 for pull-ups

3.12. Function Pins

3.12.1. MAIN_RI

pin name	typology	serial number	voltage domain	corresponds English -ity, -ism, -ization
MAIN_RI	DO	20	LDOAON	Ringer signal, wake-up output pin, used to wake up the AP

Tables 10 : MAIN_RI Signal Action

state of affairs	MAIN_RI answer
pragmatic	high level
voice call	goes low, after that: （1） Goes high when the call is established （2） Using the AT command ATH hangs up the voice and MAIN_RI goes high （3） Caller hangs up, MAIN_RI first goes high, then pulls low for 120ms, receives auto-reply URC message "NO CARRIER", then goes high again after that （4） Goes high when a text message is received
data transmission	goes low, after that: 1. Goes high when a data connection is established 2. Use the AT command ATH to hang up the data connection, MAIN_RI goes high 3. Caller hangs up, MAIN_RI first goes high, then pulls low for 120ms, receives auto-reply URC message "NO CARRIER", then goes high again after that 4. Goes high when a text message is received
text messaging	When a new SMS is received, MAIN_RI goes low for 120ms and goes high again
URC	Certain URC messages can trigger MAIN_RI to pull down for 120ms.

If the module is used as the calling party, MAIN_RI will remain high, except when a URC message or SMS is received. And when the module is used as the called party, the timing of MAIN_RI is shown below:

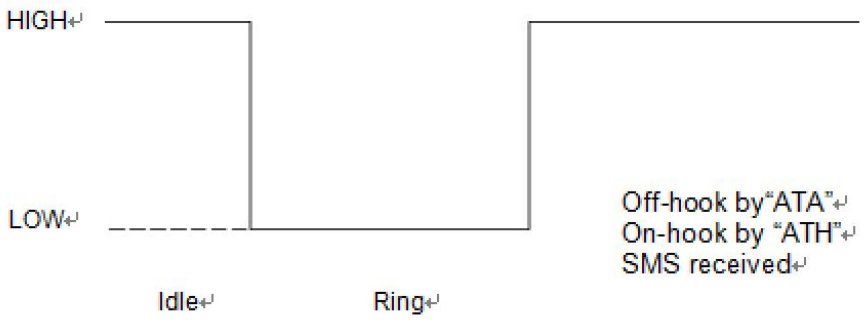


Chart 12 : Voice Module used as called party MAIN_RI timing during a call

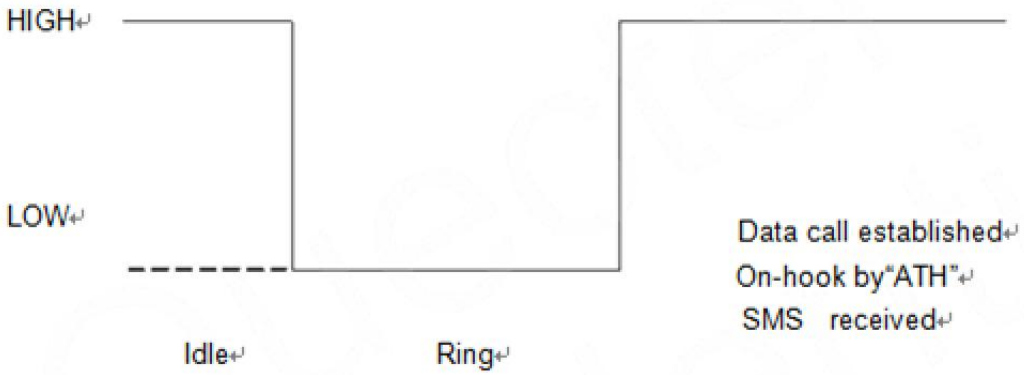


Chart 13 : Module used as called party MAIN_RI timing for data calls

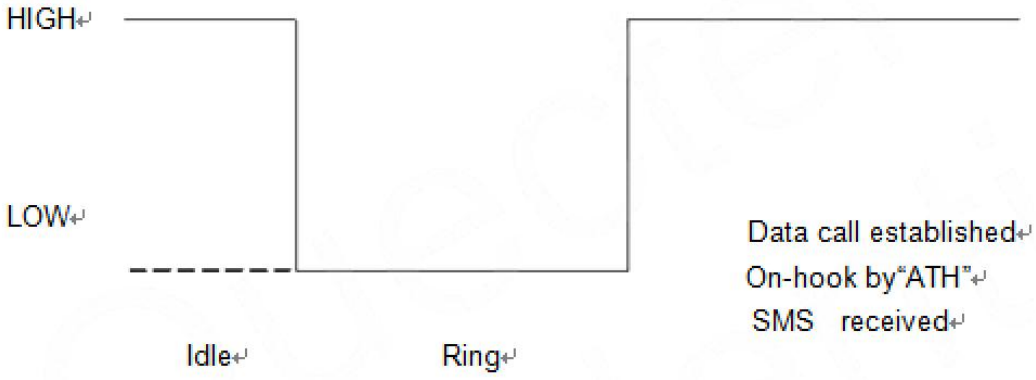


Chart 14 : MAIN_RI Timing for Module Calls

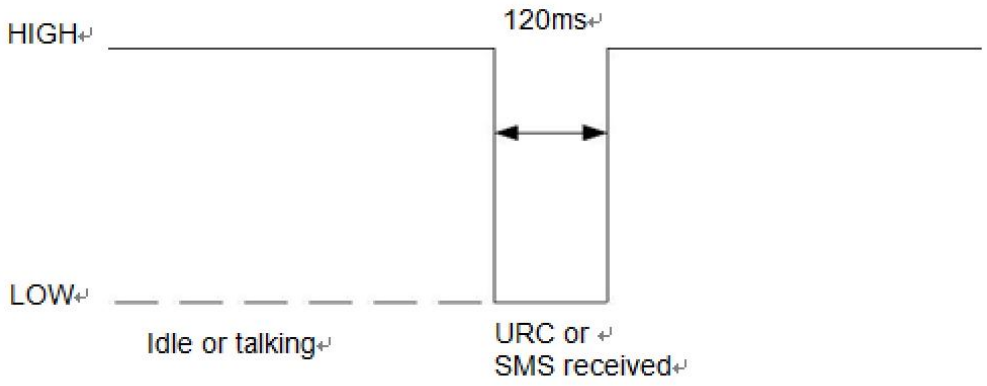


Chart 15 : MAIN_RI timing when receiving URC messages or SMS messages

3.12.2. MAIN_DTR

pin name	typology	serial number	voltage domain	corresponds English -ity, -ism, -ization
MAIN_DTR	DI	19	LDOAON	Module sleep wake-up pin, pull high to allow the module to enter sleep mode; in sleep mode, pull low to wake up the module

The module supports two sleep modes:

Sleep mode 1: send AT+CSCLK=1 to control whether the module goes to sleep or not by MAIN_DTR pin level

Sleep mode 2: send AT+CSCLK=2, the module automatically enters sleep after the serial port has been idle for a period of time

For details, refer to 3.20.2 Sleep mode

3.12.3. Status Indicator

The Air780E uses a pin signal to indicate the state of the network. The following two tables describe the pin definition and the logic level changes for different network states:

Tables 11 : Network Indication Pin Definitions

pin name	typology	serial number	voltage domain	corresponds English -ity, -ism, -ization

NET_STATUS	DO	16	LDOAON	Indicates the network operational status of the module

Tables 12 : Indicates the operating status of the network pins

state of affairs	Pin operating status	network state
NET_STATUS	Lights up for 0.2	search network status
	1.8 seconds on, 0.2	pragmatic
	Lights up for 0.125 seconds, goes out for 0.125 seconds	data transmission status Note: This status indication is limited to PPP dialling success or AT command active PDP activation success and RNDIS networking success.

The indicator reference circuit is shown below:

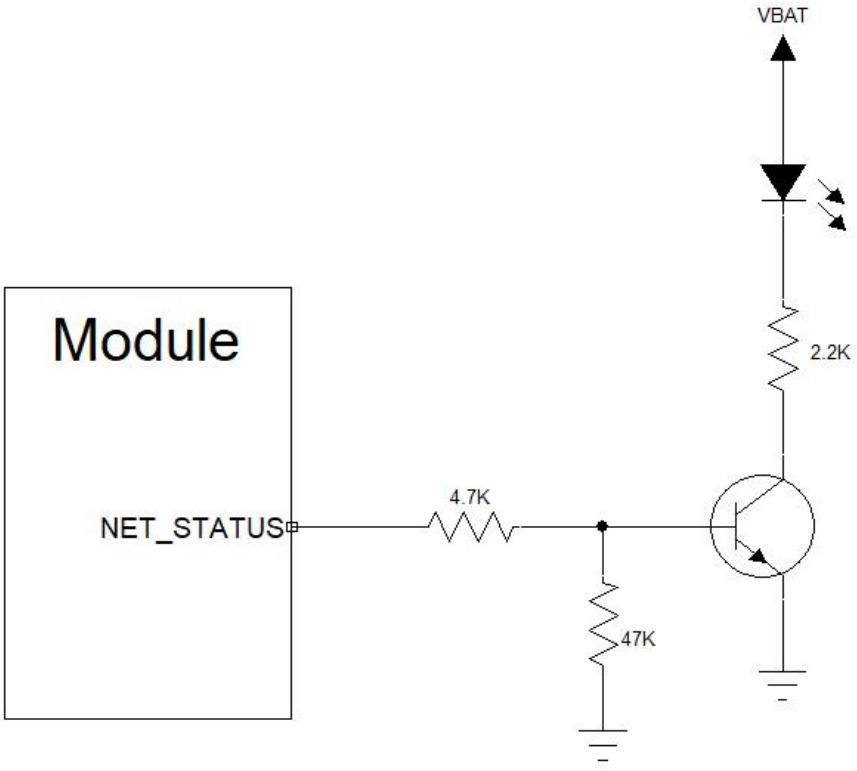


Chart 16 : Indicator Light Reference Circuit

3.13. power saving feature

Depending on the system requirements, there are two ways to put the module into a low power state. For the

AT version, the "AT+CFUN" command can be used to put the module into the least functional state.

3.13.1. Minimum Function Mode/Flight Mode

Minimum function mode can reduce the module function to minimum, this mode can be set by sending "AT+CFUN=<fun>" command. The <fun> parameter can be selected from 0, 1, 4.

- 0: Minimum function (disable RF and SIM card);
- 1: Full function (default);
- 4: Disable the RF send and receive function;

If you use "AT+CFUN=0" to set the module to least functional mode, the functions of the RF section and SIM section will be switched off. The serial port is still valid, but the AT commands related to the RF section and SIM card section are not available.

If you use "AT+CFUN=4" to set the module, the RF part of the function will be disabled, while the serial port is still valid. All AT commands related to the RF part are not available.

After the module is set by "AT+CFUN=0" or "AT+CFUN=4", it can be set to return to the full-function state by "AT+CFUN=1" command. state.

3.13.2. Sleep mode (slow clock mode)

3.20.2.1 Serial port applications

Two sleep modes are supported under serial applications:

- Sleep Mode 1: Controls whether the module goes to sleep or not via MAIN_DTR pin level
- Sleep mode 2: the module automatically enters sleep after the serial port has been idle for a period of time

3.20.2.1.1 Sleep mode 1

Opening conditions:

Send AT command AT+CSCLK=1

The module goes to sleep:

Controlling the MAIN_DTR pin to pull high, the module will enter sleep mode 1

The module exits sleep:

Pull down the MAIN_DTR pin for more than 50ms, the module will exit the sleep mode can accept the AT instruction

Software function of the module in sleep mode 1:

Doesn't respond to AT commands, but receives data/SMS/incoming calls with URC reporting

How to wake up the HOST when the module receives data/SMS/incoming calls while the HOST is sleeping:

MAIN_RI Signal

3.20.2.1.2 Sleep mode 2

Opening conditions:

Send AT command AT+CSLCK=2

The module goes to sleep:

The serial port is idle for more than the time configured by AT+WAKETIM (default 5s), the module automatically enters sleep mode 2

The module exits sleep:

The serial port continuously sends AT until the module responds then it exits sleep mode 2

Software function of the module in sleep mode 2:

Doesn't respond to AT commands, but receives data/SMS/incoming calls with URC reporting

How to wake up the HOST when the module receives data/SMS/incoming calls while the HOST is sleeping:

MAIN_RI signal

3.20.2.2 USB applications

Opening conditions:

USB HOST must support USB suspend/resume.

The module goes to sleep:

HOST initiates USB suspend

The module exits sleep:

HOST initiates USB resume

How to wake up the HOST when the module receives data/SMS/incoming calls while the HOST is sleeping:

MAIN_RI signal

3.14. Mode switching summary

Tables 13 : Summary of mode switching

current mode	Next mode		
	finish shooting a film	normal mode	sleep mode
finish shooting a	/	Booting with PWRKEY	/
normal mode	Using the PWRKEY pin, or VBAT voltage below the shutdown voltage	/	Software call sleep interface, AT version does not do the action of 30s automatic hibernation

sleep mode	Using the PWRKEY pin, or VBAT voltage below the shutdown voltage	GPIO pin interrupt, timer, receive SMS or network data	/

For specific power consumption data, please consult 5.4 Power Consumption section.

4. RF interface

The antenna interface pins are defined below:

Tables 14 : RF_ANT Pin Definitions

pin name	serial number	descriptions
LTE_ANT	35	LTE Antenna Interface

4.1. RF reference circuit

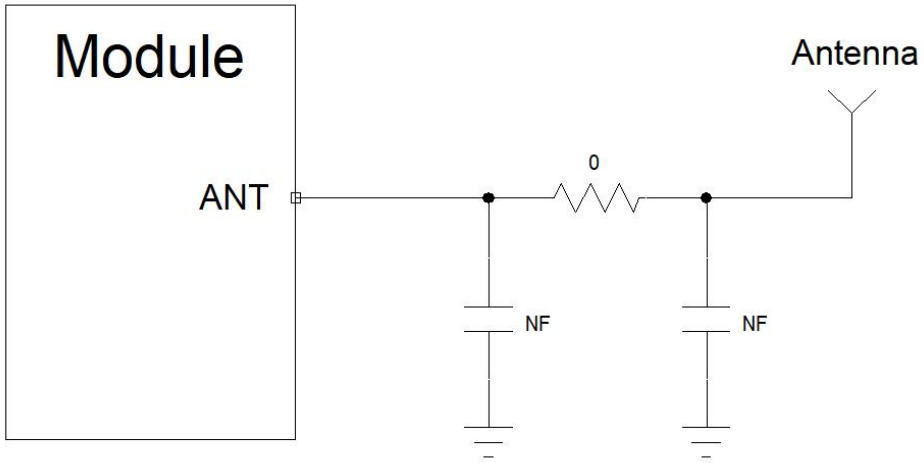


Chart 17 : RF Reference Circuit

Attention:

- The RF traces connected to the module RF antenna pads must be microstrip or other types of RF traces with an impedance of about 50 ohms.
- Reserve the Π-type matching circuit near the antenna, the two capacitors are not patched by default, and the resistor is patched with 0 ohm by default, and the matching circuit will be patched with the actual debugging after the antenna factory debugs the antenna;
- Luat module impedance line and antenna design recommendations: https://doc.openluat.com/article/2430

4.2. RF Output Power

Tables 15 : RF Conducted Power

(radio) band	greatest	minimal
LTE FDD B1/B3/B5/B8	23dBm +-2dB	<-44dBm
LTE TDD B34/38/B39/B40/B41	23dBm +-2dB	<-42dBm

4.3. RF conduction sensitivity

Tables 16 : RF Conductivity Sensitivity

(radio) band	receiver sensitivity
LTE FDD B1 (10M)	< -99dBm
LTE FDD B3 (10M)	< -99dBm
LTE FDD B5 (10M)	< -99dBm
LTE FDD B8 (10M)	< -99dBm
LTE TDD B34 (10M)	< -100dBm
LTE TDD B38 (10M)	< -99dBm
LTE TDD B39 (10M)	< -100dBm
LTE TDD B40 (10M)	< -99dBm
LTE TDD B41 (10M)	< -99dBm

4.4. operating frequency

3GPP frequency band	sending	reception (of transmitted signal)	unit (of measure)
LTE-FDD B1	1920~1980	2110~2170	MHz

LTE-FDD B3	1710~1785	1805~1880	MHz
LTE-FDD B5	824~849	869~894	MHz
LTE-FDD B8	880~915	925~960	MHz
LTE-TDD B34	2010~2025	2010~2025	MHz
LTE-TDD B38	2570~2620	2570~2620	MHz
LTE-TDD B39	1880-1920	1880-1920	MHz
LTE-TDD B40	2300~2400	2300~2400	MHz
LTE-TDD B41	2555~2655	2555~2655	MHz

4.5. Recommended RF Soldering Methods

If the RF connector connecting the external antenna is connected to the module by soldering, please be sure to pay attention to the stripping method of the connecting wires and the soldering method, especially the ground should be soldered sufficiently, please follow the correct soldering method in the following figure to avoid the increase of the wire loss caused by the poor soldering.

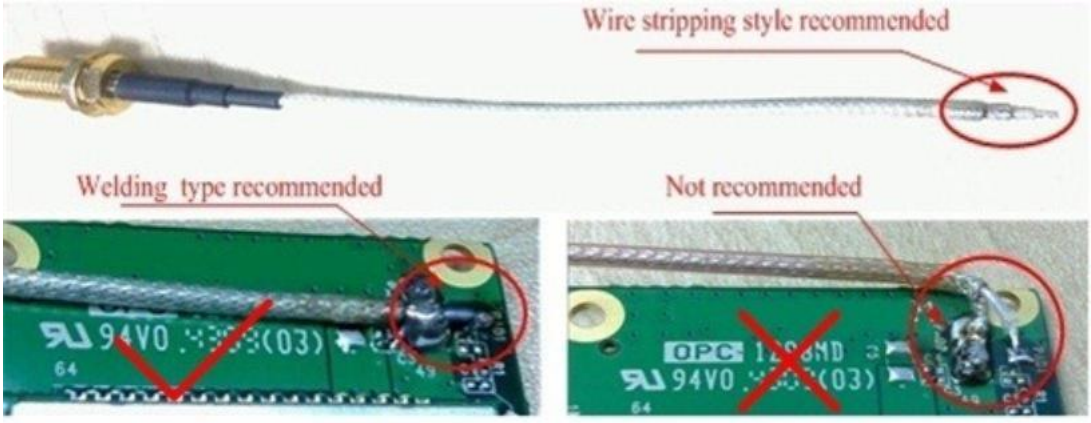


Chart 18 : Recommendations for RF Welding Methods

5. Electrical Characteristics, Reliability, RF Characteristics

5.1. absolute maximum

The following table shows the maximum withstand values for the power supply voltage and current for the digital and analogue pins of the module.

Tables 17 Absolute Maximum

parametric	minimal	greatest	unit (of measure)
V_{BAT}	-0.3	4.7	V
VBUS	-0.3	5.5	V
Power supply peak current	0	1.5	A
Power supply average current (TDMA one frame time)	0	0.7	A
Voltage at digital pins	-0.3	3.6	V
Voltage at analogue pin (ADC)	-0.3	3.6	V

5.2. Recommended working conditions

Tables 18 : Recommended Conditions of Work

parameters	minimal	quintessential	greatest	unit (of measure)
V_{BAT}	3.3	3.8	4.3	V
VBUS	3.3	5.0	5.25	V

5.3. operating temperature

Tables 19 : Operating Temperature

temp	lowest	quintessential	supreme	unit (of measure)
normal working temperature	-35	25	75	℃
Limit working temperature	-40~-35		75~85	℃

Storage temperature	-45		90	℃

5.4. power wastage

5.4.1. Module Operating Current

Test equipment: IMRT R&S CMW500, programme controlled power supply Agilent 66319D

Test conditions: VBAT=3.8V, ambient temperature 25℃, insert white card, connect CMW500 synthesizer

parametric	test condition		minimal	quintessential	greatest	unit (of measure)
I_{VBAT}	leakage current	First time on the power.		1		uA
		Power on and off (RTC working properly)		1		uA
	Sleep Standby Current	LTE-FDD @PF=32		1.2		mA
		LTE-FDD @PF=64		0.68		mA
		LTE-FDD @PF=128		0.43		mA
		LTE-FDD @PF=256		0.33		mA
		LTE-TDD @PF=32		1.12		mA
		LTE-TDD @PF=64		0.68		mA
		LTE-TDD @PF=128		0.43		mA
		LTE-TDD @PF=256		0.35		mA
	Idle Mode Current	LTE-FDD @PF=64		3.78		mA
		LTE-TDD @PF=64		3.77		mA
	Flight Mode AT+CFUN=4, AT+CSCLK=3	Average current (1.8V IO level)		157		uA
		Bottom current (1.8V IO level)		37		uA
		Average current (3.3V IO level)		228		uA
		Bottom current (3.3V IO level)		60		uA

	LTE-FDD B1 CH300 BW=10M	TX power = 23dbm		424		mA
	LTE-FDD B3 CH1575 BW=10M	TX power = 23dbm		406		mA
	LTE-FDD B5 CH2525 BW=10M	TX power = 23dbm		389		mA
	LTE-FDD B8 CH3625 BW=10M	TX power = 23dbm		434		mA
	LTE-TDD B34 CH36275 BW=10M	TX power = 23dbm		172		mA
	LTE-TDD B38 CH38000 BW=10M	TX power = 23dbm		234		mA
	LTE-TDD B39 CH38450 BW=10M	TX power = 23dbm		164		mA
	LTE-TDD B40 CH39150 BW=10M	TX power = 23dbm		263		mA
	LTE-TDD B41 CH40620 BW=10M	TX power = 23dbm		236		mA

5.4.2. Real network simulation of long connection power consumption

Test Instrument: Programmable Power Supply Agilent 66319D

Test conditions: VBAT=3.8V, ambient temperature 25° C

test environment	open net	Mobile BAND40	Unicom BAND1	Telecommunications BAND1
Paging cycle		0.64S	1.28S	1.28S
signal quality	AT+CESQ	60	54	54
Sleep Current	AT+CSCLK=2	0.58 mA	0.45 mA	0.43 mA
TCP heartbeat packet guaranteed live	AT+CSCLK=2, once a minute	2.74mA	2.71 mA	2.57 mA
	AT+CSCLK=2, once every 5 minutes	1.05 mA	0.94 mA	0.93 mA

TCP heartbeat packet guaranteed live Ultra Low Power Mode	AT+CSCLK=3,once a minute (AT+WAKETIM=1, AT*RTIME=1)	1.27 mA	0.97 mA	1.13 mA
	AT+CSCLK=3,5 mins. (AT+WAKETIM=1, AT*RTIME=1)	0.74 mA	0.61 mA	0.68 mA

Attention:

Since this is a real network test, network signal strength, registration band, server response time will have a greater impact on the value of the test, therefore, this data is for reference only.

5.5. electrostatic protection

In the module application, due to human body static electricity, microelectronics between the charged friction and other static electricity, through a variety of ways to discharge to the module, may cause some damage to the module, so the ESD protection must pay attention to, no matter in the production and assembly, testing, R & D and other processes, especially in the design of the product should be taken to prevent ESD protection measures. Such as circuit design at the interface or vulnerable to ESD points to increase ESD protection, production with anti-ESD gloves and so on.

The following table shows the ESD withstand voltage of the module's key PIN pins.

Forms 20 ESD performance parameters (temperature: 25°C, humidity: 45 per cent)

pin name	contact discharge	air discharge
VBAT,GND	±5KV	±10KV
LTE_ANT	±5KV	±10KV
Others	±0.5KV	±1KV

6. Module Dimensions Fig.

This section describes the mechanical dimensions of the module and the recommended package size for customer designs using the module.

6.1. Recommended PCB Packages

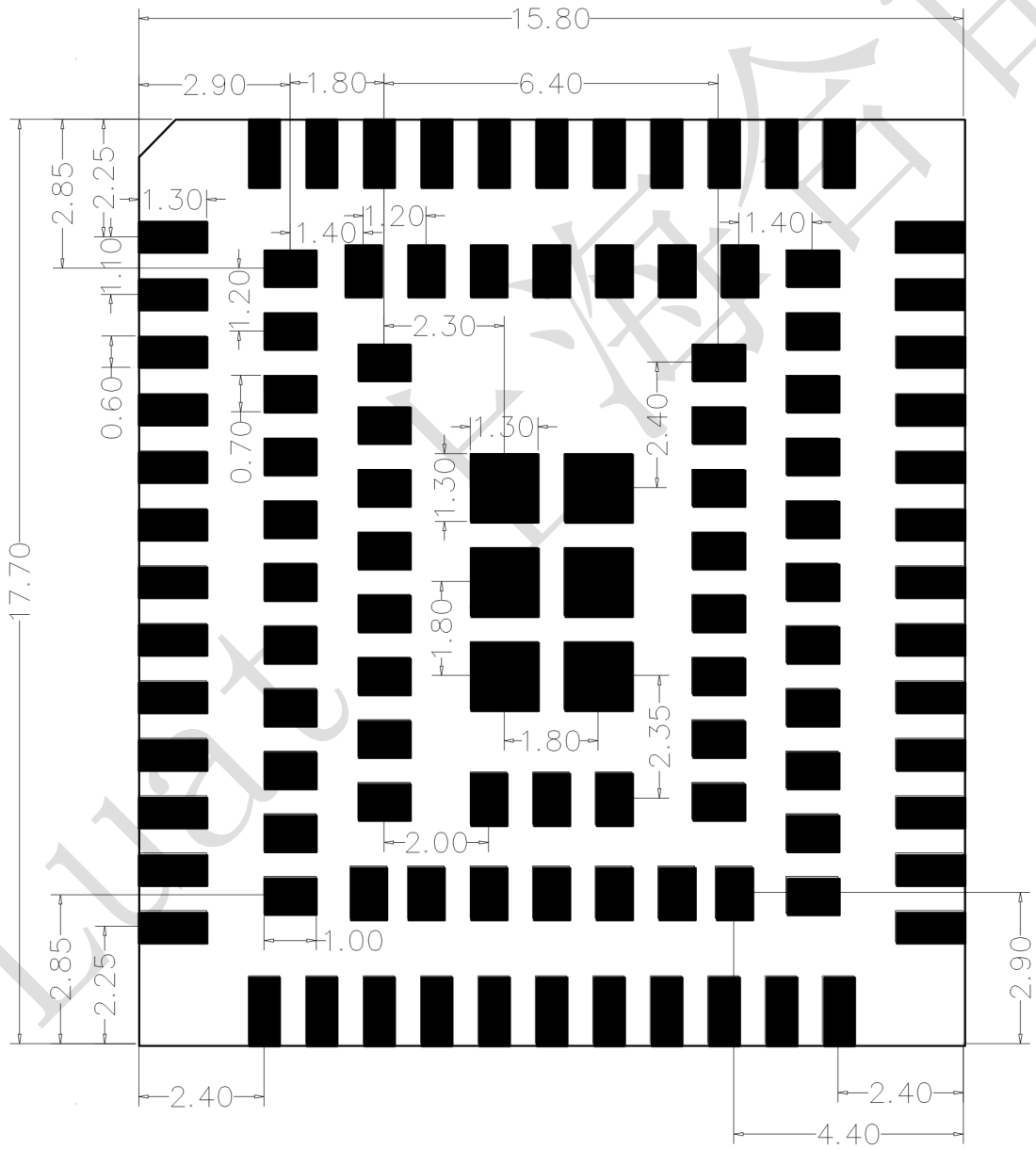


Chart 19 : Front View, Air780E PCB Package (in mm)

Attention:

1. The spacing between modules and other components on the **PCB** is recommended to be at least **3mm;**
2. Please visit: https://www.openluat.com/ for a library of schematic PCB packages for the module.

7. Storage and production

7.1. stockpile

The Air780E is shipped in vacuum sealed bags. Storage of the modules is subject to the following conditions:

Modules can be stored in vacuum sealed bags for 12 months at ambient temperatures below 40 degrees Celsius and air humidity less than 90%.

When the vacuum sealed bag is opened, the module can be directly reflowed or other high temperature processes if the following conditions are met:

- Module ambient temperature is less than 30 degrees Celsius, air humidity is less than 60 per cent, and the factory completes the patch in less than 72 hours.
- Air humidity less than 10 per cent

If the module is in the following conditions, it needs to be baked before placement:

- Humidity indicator card shows humidity greater than 10% when the ambient temperature is 23 degrees Celsius (5 degrees Celsius fluctuation allowed).
- When the vacuum-sealed bag is opened, the module ambient temperature is less than 30 degrees Celsius and the air humidity is less than 60 per cent, but the factory fails to complete the patch in less than 72 hours
- Module storage air humidity greater than 10% when vacuum sealed bag is opened

If the modules need to be baked, bake them at 125 degrees Celsius (allowing for fluctuations of 5 degrees Celsius up or down) for 48 hours.

NOTE: The module packaging cannot withstand such high temperatures, remove module packaging before baking the module. If only a short baking time is required, please refer to **IPC/JEDECJ-STD-033** specification.

7.2. Production welding

Use the printing squeegee to print solder paste on the stencil, so that the solder paste through the opening of the stencil leakage printed on the PCB, the strength of the printing squeegee needs to be adjusted appropriately, in order to ensure the quality of the module printing paste, Air780E module pad part of the corresponding thickness of the stencil should be 0.2mm.

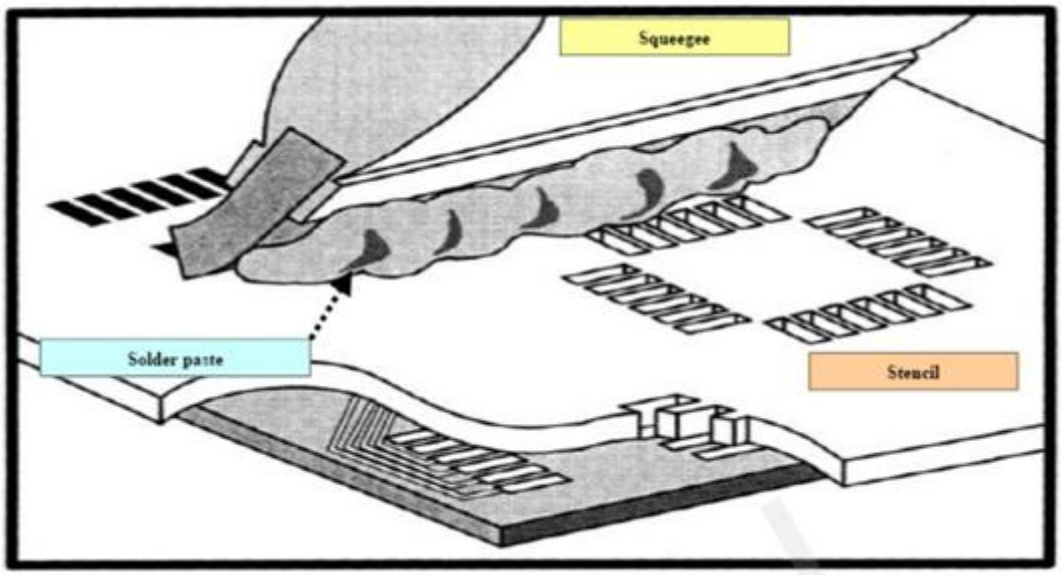


Chart 20 : Printing Paste Chart

In order to avoid repeated heat damage to the module, it is recommended that customers reflow the first side of the PCB board before attaching the module. The recommended oven temperature profile is shown below:

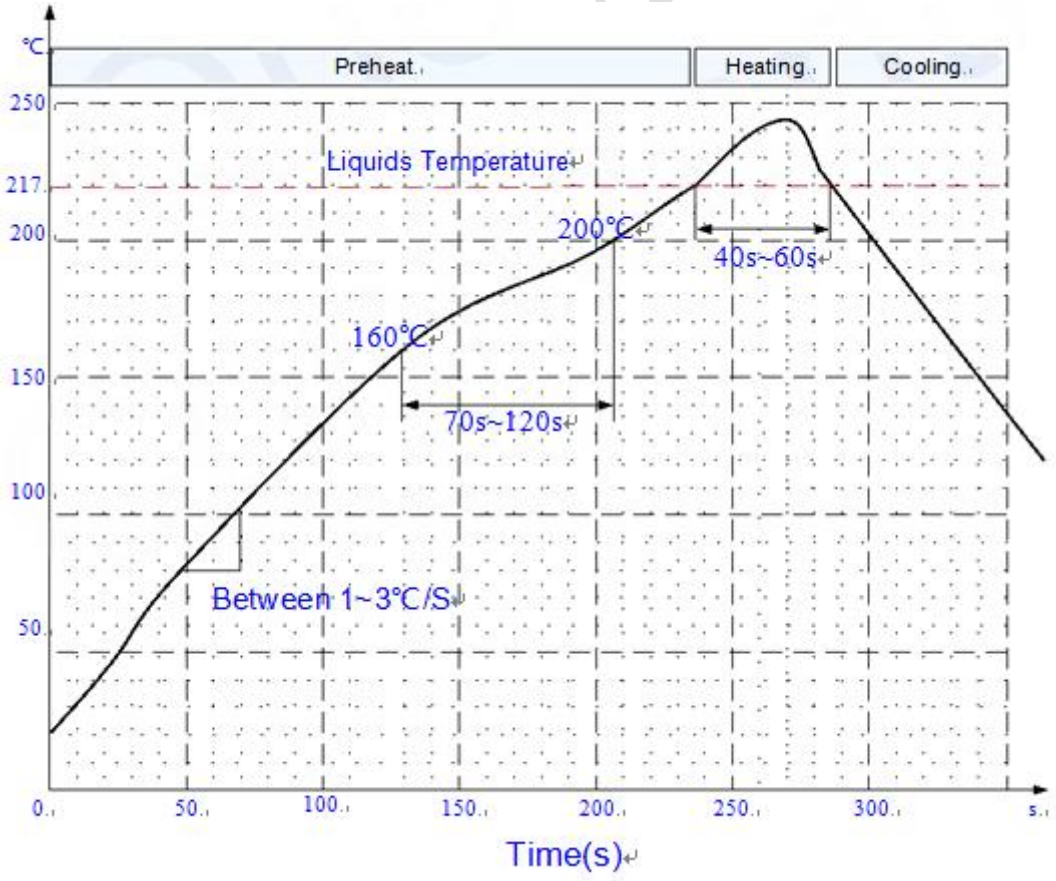


Chart 21 : Furnace Temperature Curve Line Chart

8. Abbreviations

Tables 21 : Abbreviations

nomenclature	Full name in English	Full name in Chinese
ADC	Analog to Digital Converter	analogue-to-digital converter
bps	Bits Per Second	bit/s
CTS	Clear to Send	Clear Send
DFOTA	Differential Firmware Over-the-Air	Wireless Differential Firmware Upgrade
DTR	Data Terminal Ready	Data Terminal Ready
ESD	Electro Static discharge	electrostatic discharge
ESR	Equivalent Series Resistance	equivalent series resistance
EVB	Evaluation Board	evaluation board
FDD	Frequency Division Duplex	frequency division duplex
FTP	File Transfer Protocol	File Transfer Protocol
FTPS	FTP-over-SSL	Extended protocols for adding Transport Layer Security (TLS) and Secure Sockets Layer (SSL) encryption support to the popular File Transfer Protocol (FTP).
GPIO	General Purpose Input Output	General purpose input and output pins
GPS	Global Positioning System	global positioning system (GPS)
HTTP	Hypertext Transfer Protocol	hypertext transfer protocol (HTTP)
HTTPS	Hypertext Transfer Protocol over Secure Socket Layer	HTTP
LCC	Leadless Chip Carriers	Square package without pins
LGA	Land Grid Array	Raster Array Package
LTE	Long Term Evolution	Long-term evolution
MQTT	Message Queuing Telemetry Transport	Message Queue Telemetry Transfer
MSL	Moisture Sensitivity Levels	Humidity sensitivity class
NITZ	Network Identity and Time Zone	Network identifiers and time zones
NTP	Network Time Protocol	network time protocol
PA	Power Amplifier	power amplifier
PCB	Printed Circuit Board	printed circuit board

PCM	Pulse Code Modulation	pulse code modulation
PDU	Protocol Data Unit	Protocol Data Unit
PMIC	Power Management IC	Power Management ICs
PPP	Point-to-Point Protocol	P2P protocol
RF	Radio Frequency	a radio frequency
RTS	Require To Send	Request sent
SMS	Short Message Service	text messaging
SSL	Secure Sockets Layer	Secure Sockets Layer (SSL) (computing)
TCP	Transmission Control Protocol	transmission control protocol
TDD	Time Division Duplexing	time division duplex
UART	Universal Asynchronous Receiver & Transmitter	universal asynchronous relay
UDP	User Datagram Protocol	UDP
UMTS	Universal Mobile Telecommunications System	Universal Mobile Communications System (UMCS)
USB	Universal Serial Bus	Universal Serial Bus, USB (computer)
(U)SIM	(Universal) Subscriber Identity Module	（User identification module (generic)
VSWR	Voltage Standing Wave Ratio	VSWR