# L600 Hardware Design

**IoT LTE Module Series**

**Version**： V1.0

**Date**： 2017-06-06

Notice

Some features of the product and its accessories described herein rely on the software installed, capacities and settings of local network, and therefore may not be activated or may be limited by local network operators or network service providers.

Thus, the descriptions herein may not exactly match the product or its accessories which you purchase. Shanghai Mobiletek Communication Ltd reserves the right to change or modify any information or specifications contained in this manual without prior notice and without any liability.

Copyright

This document contains proprietary technical information which is the property of Shanghai Mobiletek Communication Ltd. copying of this document and giving it to others and the using or communication of the contents thereof, are forbidden without express authority. Offenders are liable to the payment of damages. All rights reserved in the event of grant of patent or the registration of a utility model or design. All specification supplied herein are subject to change without notice at any time.

DISCLAIMER

ALL CONTENTS OF THIS MANUAL ARE PROVIDED "AS IS". EXCEPT AS REQUIRED BY APPLICABLE LAWS, NO WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE MADE IN RELATION TO THE ACCURACY, RELIABILITY OR CONTENTS OF THIS MANUAL.

TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, IN NO EVENT SHALL SHANGHAI MOBILETEK COMMUNICATION LTD BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT, OR CONSEQUENTIAL DAMAGES, OR LOSS OF PROFITS, BUSINESS, REVENUE, DATA, GOODWILL SAVINGS OR ANTICIPATED SAVINGS REGARDLESS OF WHETHER SUCH LOSSES ARE FORSEEABLE OR NOT.

Version History

| Date | Version | Description of change | Author |
|------|---------|----------------------|--------|
| 2017-06-06 | V1.0 | Initial | |
| | | | |
| | | | |
| | | | |
| | | | |

# Contents

# 1 About this document

## 1.1 Applicable scope

This document describes the L600 series 4G LTE CAT-M1 and NB-IoT LCC Module (hereinafter referred to as L600), the basic specifications, product electrical characteristics, design guidance and hardware interface development guidance. Users need to follow this documentation requirements and guidance for design.

This document applies only to L600 series products in the application development.

## 1.2 Writing purpose

This document provides the design and development basis for the product users. By reading this document, users can have a whole understanding of the product, the technical parameters of the product have a clear understanding, and can be used in this document to complete the development of wireless LTE CAT-M1 and NB-IOT Internet access functions.

This hardware development document not only provides the product functional features and technical parameters, but also provides product reliability testing and related testing standards, business functions to achieve process, RF performance indicators and user circuit design guidance.

## 1.3 Support and reference documents list

In addition to the hardware development documentation, we also provide a guide to the development board based on this product manual and software development instruction manual, 1-1 is supported as a list.

Table 1-1 support document list

| No. | Documents |
|-----|-----------|
| 1 | 《L600 AT Command User Guide》 |
| 2 | 《L600_SPEC.docx》 |
| 3 | 《L600 EVB User Manual》 |
| 4 | 《L600 Schematic checklist》 |
| 5 | 《L600 Layout checklist》 |
| 6 | 《L600_Reference Design_V1.pdf》 |
| 7 | 《L600_V1_DECAL.sch》 |

| 8 | 《L600_V1_DECAL.PCB》 |

# 1.4 Terms and Abbreviations

Table 1-2 is the Document relative Terms and Abbreviations。

Table 1-2    Terms and Abbreviations

| Abbreviation | Descriptions |
|---|---|
| ESD | Electro-Static discharge |
| USB | Universal Serial Bus |
| UART | Universal Asynchronous Receiver Transmitter |
| SDCC | Secure Digital Card Controller |
| USIM | Universal Subscriber Identification Module |
| SPI | Serial Peripheral Interface |
| I2C | Inter-Integrated Circuit |
| PCM | Pulse-coded Modulation |
| I/O | Input/output |
| LED | Light Emitting Diode |
| GPIO | General-purpose Input/Output |
| GSM | Global Standard for Mobile Communications |
| GPRS | General Packet Radio Service |
| WCDMA | Wideband Code Division Multi Access |
| UMTS | Universal Mobile Telecommunication System |
| HSDPA | High Speed Downlink Packet Access |
| HSUPA | High Speed Uplink Packet Access |
| AGPS | Assisted Global Positioning System |
| BER | Bit Error Rate |
| DL | Downlink |
| COEX | WLAM/LTE-ISM coexistence |
| SMPS | Switched-mode power supplies |
| LTE | Long Term Evolution |
| FDD | Frequency Division Duplexing |
| TDD | Time Division Duplexing |

| DPCH | Dedicated Physical Channel |
|---|---|
| DPCH_Ec | Average energy per PN chip for DPCH. DPCH |
| IoT | Internet of Things |

# 2 Product Overview

L600 is a series of LTE CAT M1 and CAT NB1 module and special design for global IoT market, and it's have integrated rich peripheral interface. User can choose the module based on the wireless network configuration. In this document, the supported radio band is described in the following items. This product is a LCC interface of 4G wireless internet module, with the high speed, small size, light weight, high reliability can be widely used in various products and devices with wireless internet access:

Table 2-1    L600 series module type correspond band

| Support band | | L600-V | L600-A | L600-C |
|---|---|---|---|---|
| LTE CAT M1 | B1 | | | ● |
| | B2 | | ● | |
| | B4 | ● | ● | |
| | B8 | | | ● |
| | B12 | | ● | |
| | B13 | ● | | |

**Data transmission specifications**

- LTE-FDD CAT M1
- Uplink up to 375k bps,
- Downlink up to 375K bps
- LTE-FDD CAT NB-IoT
- Uplink up to 70k bps,
- Downlink up to 32K bps

Interface

- USB2.0
- UART
- USIM (3V/1.8V)
- GPIO
- ADC
- PCM
- SPI
- I2C
- NETLIGHT
- POWER KEY
- RESET

Dimensions（L×W×H）:25mm×21.5mm×2.6mm

TOP VIEW                    BOTTOM VIEW                    SIDE VIEW
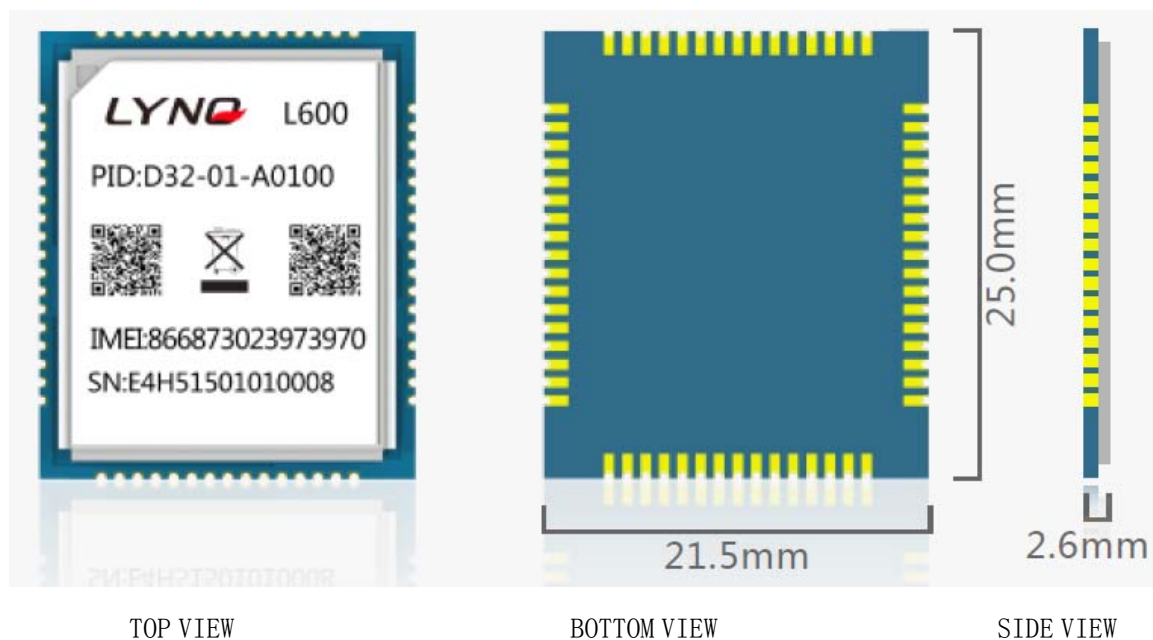
Figure 2-1    Product Physical Map

## 2.1 Package Dimensions

The product module is 64-PIN LCC package module. The size of L600 is extremely small, it is only 21.5.0 x 25.0 x 2.6 mm with LCC package, It is cost competitive and high integrated which make it convenient for customer to design their own application products. Pin 1 position from the bottom of the belt angle welding plate to identify, the missing corner where the direction of the corresponding module angle pad, figure 2-2 is the product dimension type map:

(a) Top Dimensions (Unit mm)                    (b) Side View (Unit mm)A



(c) Bottom Dimensions (Unit mm)

*Note: BGA test pin in actual use of the customers don't need (PCB assembly, the stencil file).*

Figure 2-2    Module Dimensions

# 2.2 Product Function Outline

### 2.2.1 Hardware Diagram

This product mainly includes the following signal group：USB Interface signal、USIM card Interface signal、I2C Interface signal、UART Interface signal、PCM Interface signal、SPI interface、Module startup、Module control signal、Power supply and ground. The global architecture of the L600 module is described in the figure below.

Figure 2-3 L600 System Functional Architecture

## 2.2.2 Radio frequency function

RF Function Overview:

● Dual -Band FULL Duplex FDD-LTE CATM1

● Dual -Band FULL Duplex FDD-LTE CATNB1

The operating frequency range of the transmitter is shown in table 2-2.

Table 2-3 RF frequency band

| Working band | Upstream band（Uplink） | Downlink frequency（Downlink） |
|---|---|---|
| FDD_LTE B1 | 1920 MHz~1980 MHz | 2110 MHz~2170 MHz |
| FDD_LTE B2 | 1850 MHz — 1910 MHz | 1930 MHz — 1990MHz |
| FDD_LTE B3 | 1710 MHz~1785 MHz | 1805 MHz~1880 MHz |
| FDD_LTE B4 | 1710 MHz~1755 MHz | 2110 MHz~2155 MHz |
| FDD_LTE B5 | 824 MHz~849 MHz | 869 MHz~894 MHz |
| FDD_LTE B8 | 880 MHz~915 MHz | 925 MHz~960 MHz |
| FDD_LTE B12 | 699 MHz~716 MHz | 729 MHz~746 MHz |
| FDD_LTE B13 | 777 MHz~787 MHz | 746 MHz~756 MHz |
| FDD_LTE B17 | 704 MHz~716 MHz | 734 MHz~746 MHz |
| FDD_LTE B18 | 815 MHz~830 MHz | 860 MHz~875 MHz |

| FDD_LTE B19 | 830 MHz~845 MHz | 875 MHz~890 MHz |
| FDD_LTE B20 | 832 MHz~862 MHz | 791 MHz~821 MHz |
| FDD_LTE B26 | 814 MHz~849 MHz | 859 MHz~894 MHz |
| FDD_LTE B28 | 703 MHz~748 MHz | 758 MHz~803 MHz |
| TDD_LTE B39 | 1880 MHz~1920 MHz | 1880 MHz~1920 MHz |

Table 2-4 Conducted transmission power

| Working Band | Max Power | Min Power |
|---|---|---|
| FDD_LTE B1 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B2 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B3 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B4 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B5 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B8 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B12 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B13 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B17 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B18 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B19 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B20 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B26 | 23dBm +/-2.7dB | <-40dBm |
| FDD_LTE B28 | 23dBm +/-2.7dB | <-40dBm |
| TDD_LTE B39 | 23dBm +/-2.7dB | <-40dBm |

Table 2-6 Reference sensitivity (QPSK)

| Channel bandwidth | | | | | | |
|---|---|---|---|---|---|---|
| E-UTRA Band | 200 KHz (CAT NB1) REF SENS (Total) | 200 KHz(CAT NB1) REF SENS (EPRE @15KHz) | 200 KHz(CAT NB1) NB-PDSCH repetitions (Total) | 200 KHz(CAT NB1) NB-PDSCH repetitions (EPRE @15KHz) | 1.4 MHz (CAT M1) | Duplex Mode |
| 1 | -110 | -120.8 | TBD | = Total – 10.8dBm | -105 | FDD |
| 2 | -110 | -120.8 | TBD | = Total – 10.8dBm | -103 | FDD |
| 3 | -110 | -120.8 | TBD | = Total – 10.8dBm | -102 | FDD |
| 4 | -- | -- | -- | -- | -105 | FDD |
| 5 | -111 | -121.8 | TBD | = Total – 10.8dBm | -104 | FDD |
| 8 | -111 | -121.8 | TBD | = Total – 10.8dBm | -103 | FDD |
| 12 | -111 | -121.8 | TBD | = Total – 10.8dBm | -103 | FDD |
| 13 | -111 | -121.8 | TBD | = Total – 10.8dBm | -103 | FDD |
| 17 | -111 | -121.8 | TBD | = Total – 10.8dBm | -- | FDD |

| 18 | -111 | -121.8 | TBD | = Total – 10.8dBm | -105 | FDD |
|----|------|--------|-----|-------------------|------|-----|
| 19 | -111 | -121.8 | TBD | = Total – 10.8dBm | -105 | FDD |
| 20 | -111 | -121.8 | TBD | = Total – 10.8dBm | -103 | FDD |
| 26 | -111 | -121.8 | TBD | = Total – 10.8dBm | -104 | FDD |
| 28 | -111 | -121.8 | TBD | = Total – 10.8dBm | -104 | FDD |
| 39 | -- | -- | -- | -- | -105 | TDD |

# 3 Interface Description

## 3.1 PIN Definition

### 3.1.1 Pin I/O parameter definition

The I/O parameter definition of the product is shown in table 3-1.

Table 3-1 I/O parameter definitions

| Pin attribute symbol | Description |
|---|---|
| PI | Power input PIN |
| PO | Power output PIN |
| AI | Analog input |
| AIO | Analog signal input/output PIN |
| I/O | Digital signal input/output PIN |
| DI | Digital signal input |
| DO | Digital signal output |
| DOH | Digital output with high level |
| DOL | Digital output with low level |
| PD | Pull down |
| PU | Pull up |
| AO | Analog output |

### 3.1.2 Pin Map

L600 is a extremely small LCC package module and special design for the IoT marketing, and it's have integrated rich peripheral interface. Such as USIM, USB ,PCM ,UART and interactive interface, detail description show as below chart. All hardware interfaces which connect L600 to customers' application platform are through 64 pins pads (Metal half hole). Figure 3-1 is L600 PIN outline diagram.
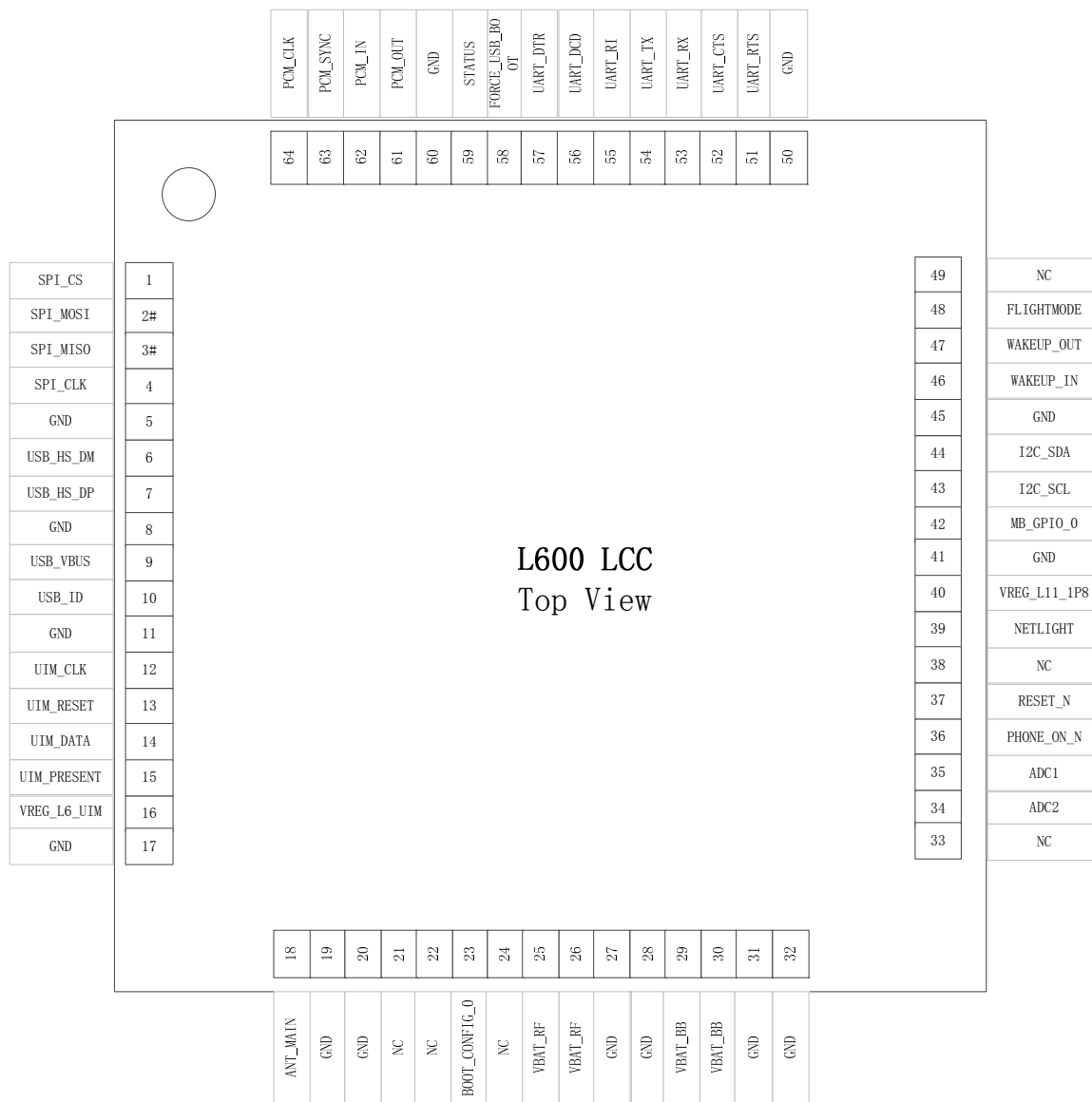
Figure 3-1 Pin Map View (Top View)

*Note:1. # flag Pin standard this pin is a Multi-function pin and it's integrated different function in different system status, and the detail function please refer to the correspond chapter.*

## 3.1.3 PIN Definition and function description

Table 3-2 Pin definition

| Pin No. | Pin description | Pin No. | Pin description |
|---------|----------------|---------|----------------|
| 1 | SPI_CS | 2 | SPI_MOSI |
| 3 | SPI_MISO | 4 | SPI_CLK |
| 5 | GND | 6 | USB_HS_DM |
| 7 | USB_HS_DP | 8 | GND |

| | | | |
|---|---|---|---|
| 9 | USB_VBUS | 10 | USB_ID |
| 11 | GND | 12 | UIM_CLK |
| 13 | UIM_RESET | 14 | UIM_DATA |
| 15 | UIM_PRESENT | 16 | VREG_L6_UIM |
| 17 | GND | 18 | ANT_MAIN |
| 19 | GND | 20 | GND |
| 21 | NC | 22 | NC |
| 23 | BOOT_CONFIG_0 | 24 | NC |
| 25 | VBAT_RF | 26 | VBAT_RF |
| 27 | GND | 28 | GND |
| 29 | VBAT_BB | 30 | VBAT_BB |
| 31 | GND | 32 | GND |
| 33 | NC | 34 | ADC2 |
| 35 | ADC1 | 36 | PHONE_ON_N |
| 37 | RESET_N | 38 | NC |
| 39 | NETLIGHT | 40 | VREG_L11_1P8 |
| 41 | GND | 42 | MB_GPIO_0 |
| 43 | I2C_SCL | 44 | I2C_SDA |
| 45 | GND | 46 | WAKEUP_IN |
| 47 | WAKEUP_OUT | 48 | FLIGHTMODE |
| 49 | NC | 50 | GND |
| 51 | UART_RTS_N | 52 | UART_CTS_N |
| 53 | UART_RX | 54 | UART_TX |
| 55 | UART_RI | 56 | UART_DCD |
| 57 | UART_DTR | 58 | FORCE_USB_BOOT |
| 59 | STATUS | 60 | GND |
| 61 | PCM_OUT | 62 | PCM_IN |
| 63 | PCM_SYNC | 64 | PCM_CLK |

Table 3-3 Pin Function Description

| Power interface | | | | |
|---|---|---|---|---|
| Pin Name | Pin No. | I/O | Description | Content |
| VBAT_BB | 29, 30 | PI | Power supply voltage, VBAT=3.4V~4.2V. | The power supply for system Maximum load current must above 2A. Keep de-cap capacitor close to the this Net. |
| VBAT_RF | 25, 26 | PI | Power supply voltage, VBAT=3.4V~4.2V. | |
| VREG_L6_UIM | 16 | PO | Module LDO output power, dual-voltage output, Max current 300mA. | Only use for external SIM Card VDD. |
| VREG_L11_1P8 | 40 | PO | Module LDO output power for MCP and accessories | If not use please let it open or add a 10 uF de-cap capacitor to ground. |
| GND | 5, 8, 11, 17, 19, 20, 27, 28, 31, 32, 41, 45, 50, 60 | -- | Ground. | |
| System control interface | | | | |
| Pin Name | Pin No. | I/O | Description | Content |
| PHONE_ON_N | 36 | DI | System power on/off input, active low. | |
| RESET_N | 37 | DI | System reset input, active low. | |
| FLIGHTMODE | 48 | DI, PU | The input signal, used to control the system into flight mode, L: flight mode; H: normal mode | Pull UP to VDD_1V8 (PIN 40) with 10K resistor |
| Interactive interface | | | | |
| Pin Name | Pin No. | I/O | Description | Content |
| NETLIGHT | 51 | DO | Identify the system network status. | |
| STATUS | 40 | DO | Module status identify: High level power on, low level | |

| | | | power off. | |
|---|---|---|---|---|
| WAKEUP_IN | 46 | DI | AP weak up module | |
| WAKEUP_OUT | 47 | DO | Module wake up AP | |

| SIM interface | | | | |
|---|---|---|---|---|
| Pin Name | Pin No. | I/O | Description | Content |
| UIM_PRESENT | 15 | DI, PU | Input pin as USIM card detect pin.<br>H: UIM is removed<br>L: UIM is inserted | If not use keep it open. |
| UIM_DATA | 14 | I/O | USIM Card data I/O, which has been pulled up with a 10KR resistor to UIM_VDD in module. Do not pull up or pull down in users' application circuit. | All signals of USIM interface should be protected with ESD/EMC. |
| UIM_RESET | 13 | DO | UIM Reset | |
| UIM_CLK | 12 | DO | UIM Clock | |
| UIM_VDD | 16 | PO | UIM Card Power output, output Voltage depends on UIM mode automatically, and one is 3.0V±10%, another is 1.8V±10%.<br>Current is less than 50mA. | |

| PCM interface | | | | |
|---|---|---|---|---|
| Pin Name | Pin No. | I/O | Description | Content |
| PCM_CLK | 64 | DO | PCM data bit clock. | If not use keep it open. |
| PCM_SYNC | 63 | DO | PCM data frame sync signal. | |
| PCM_IN | 62 | DI | PCM data input. | |
| PCM_OUT | 61 | DO | PCM data output. | |

| FULL UART | | | | |
|---|---|---|---|---|
| Pin Name | Pin No. | I/O | Description | Content |
| RTS | 51 | DI | DET Request to send. | If not use keep it open. |

| CTS | 52 | DO | Clear to Send. | If not use keep it open. |
|---|---|---|---|---|
| RX | 53 | DI | Receive Data. | If not use keep it open. |
| RI | 55 | DO | Ring Indicator. | If not use keep it open. |
| DCD | 56 | DO | Carrier detects. | If not use keep it open |
| TX | 54 | DO | Transmit Data. | If not use keep it open. |
| DTR | 57 | DI | DTE get ready. | If not use keep it open. |
| **DEBUG PORT(Multiplex)** | | | | |
| SPI_MOSI(MDM_DBG_UART_TX) | 2 | DI | Before system On: module UART debug port System On: SPI_MOSI | Suggest add test point |
| SPI_MISO(MDM_DBG_UART_RX) | 3 | DO | Before system On: module UART debug port System On: SPI_MISO | Suggest add test point |
| **I2C interface** | | | | |
| Pin Name | Pin No. | I/O | Description | Content |
| I2C_SCL | 43 | DO | I2C clock output. | If not use keep it open. |
| I2C_SDA | 44 | I/O | I2C data input/output. | |
| **RF port** | | | | |
| Pin Name | Pin No. | I/O | Description | Content |
| MAIN _ANT | 18 | AIO | Main Antenna | |
| **Others** | | | | |
| Pin Name | Pin No. | I/O | Description | Content |
| ADC1 | 35 | AI | Analog conversion digital input interface1 | If not use keep it open. |
| ADC2 | 34 | AI | Analog conversion digital input interface2 | |
| FORCE_USB_BOOT | 58 | I/O | Pull up to 1.8V (L600 VDD_1V8) with 10K resistor force module in USB download mode | Recommend placing test points for debug. |
| BOOT_CFG0 | 23 | DI, PD | Pull up to 1.8V (L600 VDD_1V8) with 10K resistor force module | |

| | | | in fastboot mode | |
|---|---|---|---|---|

## 3.2 **Operating condition**

Table 3-4 module recommended operating condition

| Parameter | Description | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| VBAT | Main power supply for the module | 3.4 | 3.8 | 4.2 | V |

# 3.3 Digital I/O characteristics

Table 3-5 1.8V Digital I/O characteristics

| Parameter | Description | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{IH}$ | High level input voltage | 0.7*VDD_PX | VDD_PX | VDD_PX+0.3 | V |
| $V_{IL}$ | Low level input voltage | −0.3 | 0 | 0.2* VDD_PX | V |
| $V_{OH}$ | High level output voltage | VDD_PX−0.45 | – | VDD_PX | V |
| $V_{OL}$ | Low level output voltage | 0 | 0 | 0.45 | V |
| $I_{OH}$ | High-level output current (no pull down resistor) | – | 2 | – | mA |
| $I_{OL}$ | Low-level output current (no pull up resistor) | – | −2 | – | mA |
| $I_{IH}$ | Input high leakage current (no pull down resistor) | – | – | 1 | uA |
| $I_{IL}$ | Input low leakage current (no pull up resistor) | −1 | – | – | uA |

*Note: 1. These parameters are for digital interface pins, such as SPI, I2C,GPIOs
UART, PCM, BOOT_CFGn.*

   *2. L600 USIM card signal (USIM_CLK, USIM_DATA, USIM_RST) support dual-voltage (1.8V and 3.0V) mode, and the DC character show in corresponding function block.*

# 3.4 Power Interface

## 3.4.1 Power supply pin description

Table 3-6 DC Power Characteristics

| Pin No. | Net Name | Description | DC Characteristic (V) | | |
|---------|----------|-------------|------|------|------|
| | | | Min. | Typ. | Max. |
| 25, 26 | VBAT_RF | Power supply for the module RF | 3.4 | 3.8 | 4.2 |
| 29, 30 | VBAT_BB | Power supply for the module BB | 3.4 | 3.8 | 4.2 |
| 5, 8, 11, 17, 19, 20, 27, 28, 31, 32, 41, 45, 50, 60 | GND | GND | – | – | – |

## 3.4.2 Power supply requirements

L600 power supply requirement as below table:

Table 3-7 VBAT power supply interface characteristics

| Symbol | Description | Min | Typ | Max | Unit |
|--------|-------------|-----|-----|-----|------|
| VBAT | Power supply voltage | 3.4 | 3.8 | 4.2 | V |
| IVBAT(peak) | Power supply p current | – | 460* | – | mA |
| IVBAT(average, Power Saving Mode disabled, Module registered with network) | Power supply average current | – | 9 | – | mA |
| IVBAT(power-off) | Power supply current in power off mode | – | – | 8 | uA |
| IVBAT(power-save mode) | Power supply current in power save mode(Deep sleep mode) | – | – | 8 | uA |

### 3.4.3 Power Supply Design Guide

Make sure that the input voltage at the VBAT pin will never drop below 3.4V even during a transmit burst when the current consumption rises up to more than 800mA. If the power voltage drops below 3.4V, the RF performance of module may be affected. Using large tantalum capacitors (above 300uF) will be the best way to reduce the voltage drops. If the power current cannot support up to 800 mA, users must introduce larger capacitor (typical 1000uF) to storage electric power. For the consideration of RF performance and system stability, some multi-layer ceramic chip (MLCC) capacitors (0.1/1uF) need to be used for EMC because of their low ESR in high frequencies. Note that capacitors should be put beside VBAT pins as close as possible. Also User should keep VBAT net wider than 2 mm to minimize PCB trace impedance on circuit board. The following figure is the recommended circuit.
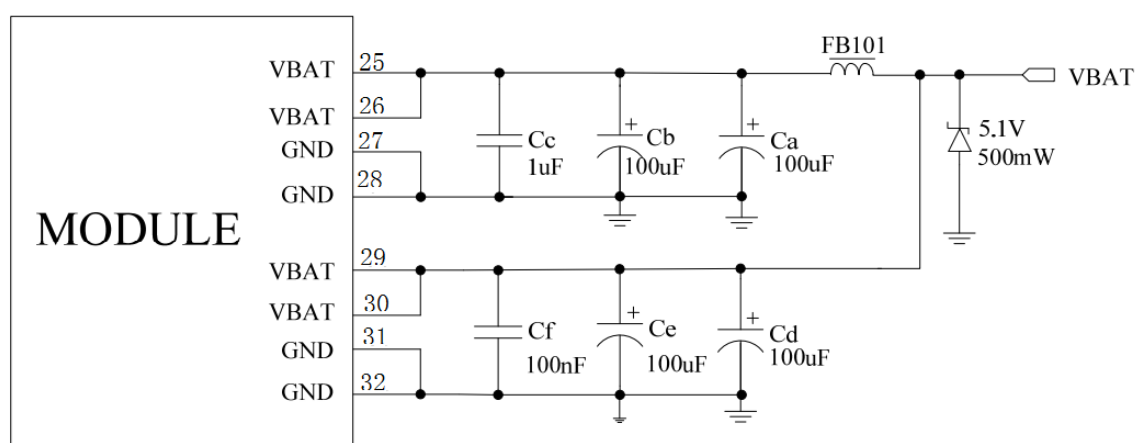
Figure 3-3 VBAT input application circuit

*Note: The Cd, Ce, Cb, Cc and Cf are recommended being mounted for L600, but the Ca, Cb, Ce, Cc and Cf for tune.*

In addition, in order to get a stable power source, it is suggested to use a Zener diode of which reverse Zener voltage is 5.1V and dissipation power is more than 500mW.

Table 3-8: Recommended Zener diode models

| NO. | Manufacturer | Part Number | Power | Package |
|-----|--------------|-------------|-------|---------|
| 1 | On semi | MMSZ5231BT1G | 500mW | SOD123 |
| 2 | Prisemi | PZ3D4V2H | 500mW | SOD123 |
| 3 | Vishay | MMSZ4689-V | 500mW | SOD123 |

## 3.4.4 Recommended Power supply circuit

If the voltage difference is not big, we recommend LDO is used for the power supply of the module, make sure that the peak current of power components can rise up to more than 800A. The following figure is the reference design of +5V input linear regulator power supply. The designed output for the power supply is 3.8V.
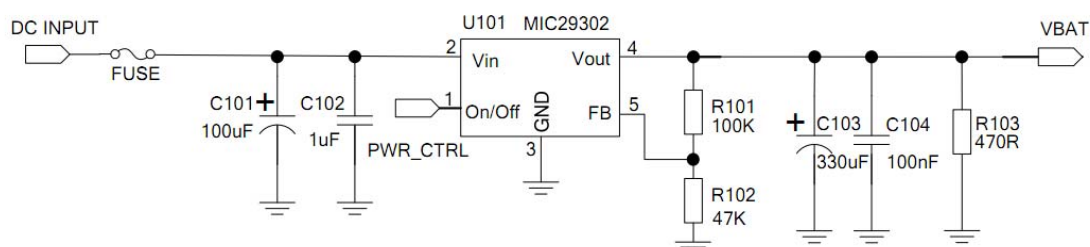


Figure 3-4 Reference circuit of the LDO power supply

If there is a big difference between the input voltage and the desired output (VBAT) or better efficiency is more important, a switching converter power (DC/DC) supply will be preferable. The following figure is the reference circuit.
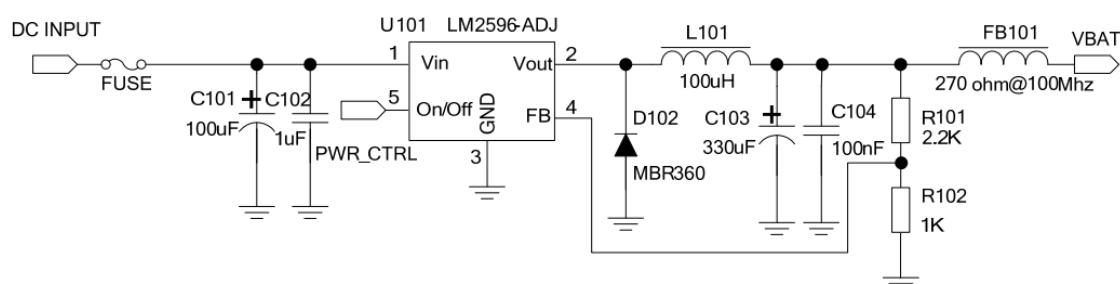


Figure 3-5 Reference circuit of the DCDC power supply

Note: DCDC may deprave RF performance because of ripple current intrinsically.

## 3.4.5 Power Supply Layout guide

The layout of the power supply section and the related components is of vital importance in the power module design. If processes this part layout is not good, will lead to various effects, such as bad EMC, effective the emission spectrum and receiving sensitivity, etc. So the power supply part design is very important, when you design this part you should notes below contents: 1. DC/DC switch power should place away from the antenna and other sensitivity circuit; 2. Consider the voltage drop and the module current requirement, the layout line should better above 100mil. If conditions allow should add a power shape plane.

# 3.5 UIM interface

## 3.5.1 Pin definition

The L600 integrated a ISO 7816-2 standard USIM port, and the module can automatic identify the voltage demo according the USIM to allow the mobile equipment to attach to the network. Both 1.8V and 3.0V SIM Cards are supported.

Table 3-9 UIM Electronic characteristic in 1.8V mode (USIM_VDD =1.8V)

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

Table 3-10: USIM Electronic characteristic 3.0V mode (USIM_VDD =3.0V)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| UIM_VDD | LDO power output | 2.75 | 3.0 | 3.05 | V |
| $V_{IH}$ | High-level input voltage | 0.65*UIM_VDD | – | UIM_VDD +0.3 | V |
| $V_{IL}$ | Low-level input voltage | -0.3 | 0 | 0.25·UIM_VDD | V |
| $V_{OH}$ | High-level output voltage | UIM_VDD -0.45 | – | UIM_VDD | V |
| $V_{OL}$ | Low-level output voltage | 0 | 0 | 0.45 | V |

## 3.5.2 Design Guide

UIM electronic characteristics as the table 3-9,3-10 show.

In order to meet the 3 GPP TS 51.010 1 protocol and EMC certification requirements. Suggest UIM slot near the location of the module USIM card interface, to avoid running for too long, lead to serious deformation of waveform and effect signal integrity, UIM_CLK and UIM_DATA signal lines suggest ground protect. Between the UIM VCC & GND add a 1uF and a 33pF capacitor in parallel, Between the SIM_CLK& GND, UIM_RST& GND, UIM DATA& GND add a 33pF capacitor in

parallel, for filter the RF signal interference.
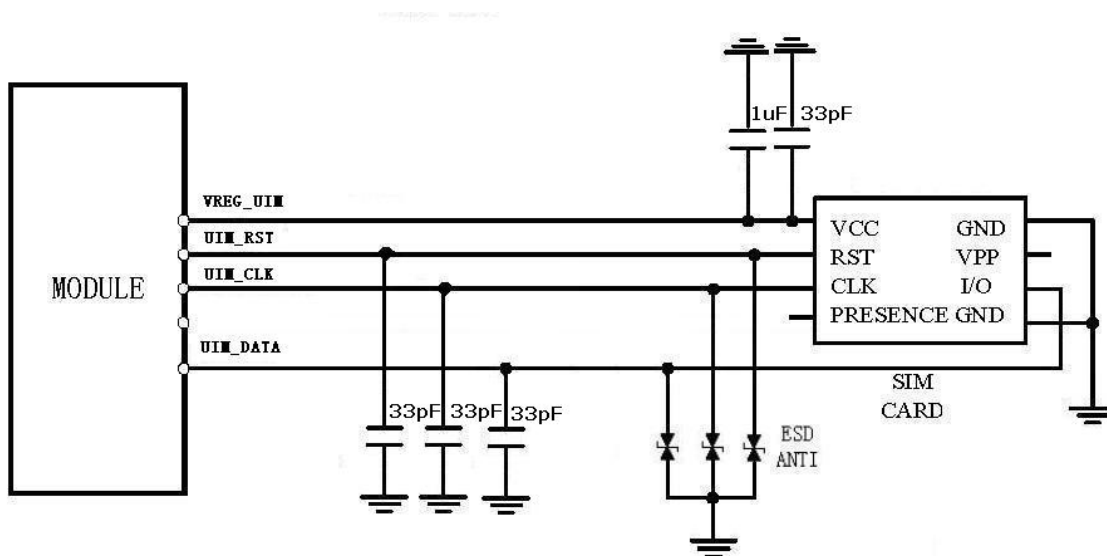
### 3.5.3 UIM interface reference circuit



Figure 3-6 UIM Reference circuit

*Note:1. UIM_DATA should have added the10K pull-up resistance to VREG_UIM in your design.*
   *2. L600 support hot-plug detect, if need the function, please add this pin, detail as the L600 reference design .*

# 3.6 PCM interface

### 3.6.1 PCM interface definition

L600 provides hardware PCM interface for external codec. L600 PCM interface can be used in short sync master mode only, and only supports 16 bits linear format:

Table 3-11 PCM interface definition

| Pin No. | Signal name | I/0 Type | DC Characteristics (V) | | |
|---------|-------------|----------|------|------|------|
| | | | Min. | Typ. | Max. |
| 63 | PCM_SYNC | PCM synchronizing signal | -0.3 | 1.8 | 1.9 |
| 62 | PCM_DIN | PCM data input | -0.3 | 1.8 | 1.9 |
| 61 | PCM_DOUT | PCM Data output | -0.3 | 1.8 | 1.9 |

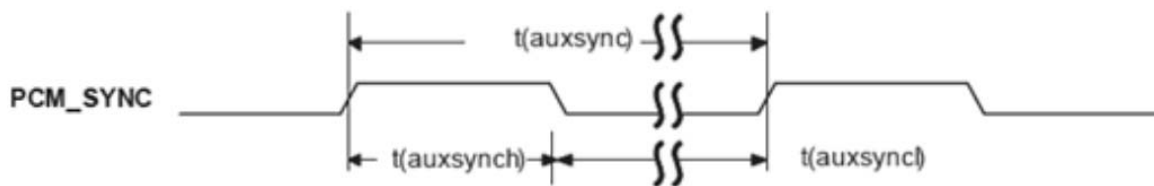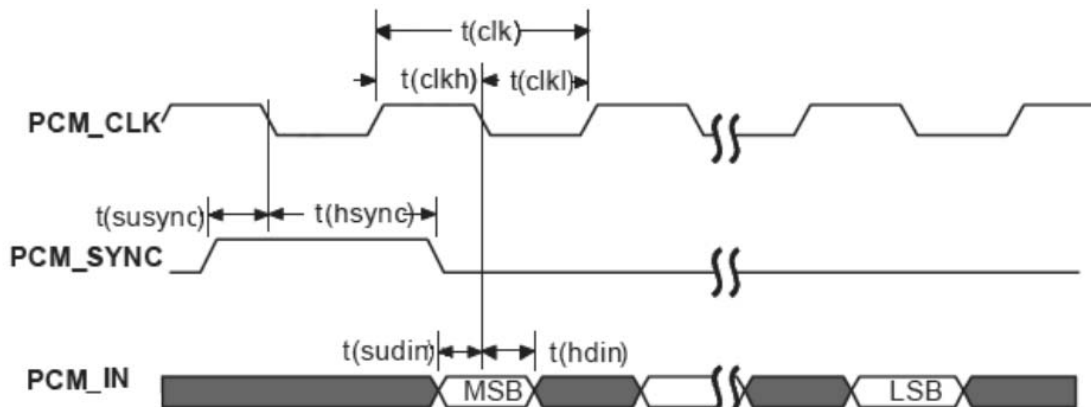| 64 | PCM_CLK | PCM Data clock | −0.3 | 1.8 | 1.9 |



Figure 3-7 PCM_SYNC timing



Figure 3-8 Codec to L600 module timing
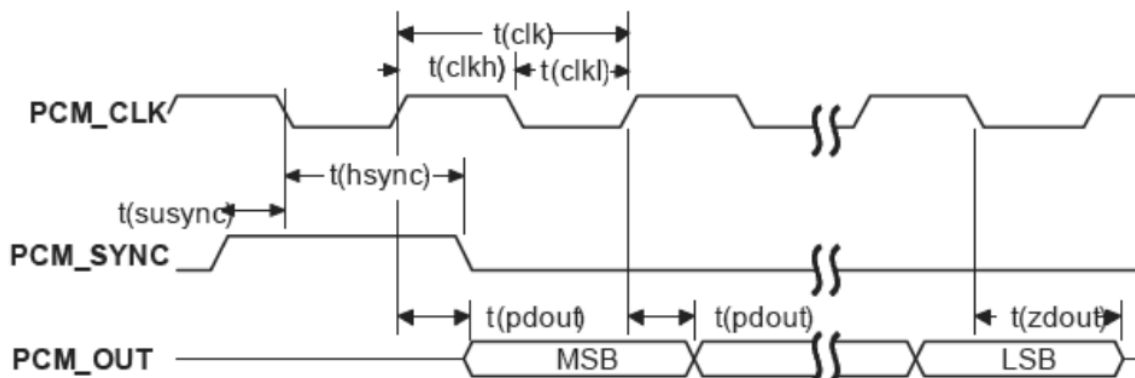


Figure 3-9 L600 to codec module timing

Table 3-12 PCM interface Timing

| Parameter | Descriptions | DC characters | | | |
| --- | --- | --- | --- | --- | --- |
| | | Min. | Typ. | Max. | Unit |
| T(sync) | PCM_SYNC cycle | – | 125 | – | us |

| T(synch) | PCM_SYNC high level hold time | – | 488 | – | ns |
|---|---|---|---|---|---|
| T(syncl) | PCM_SYNC low level hold time | – | 124.5 | – | us |
| T(clk) | PCM_CLK cycle | – | 488 | – | ns |
| T(clkh) | PCM_CLK high level hold time | – | 244 | – | ns |
| T(clkl) | PCM_CLK low level hold time | – | 244 | – | ns |
| T(susync) | PCM_SYNC establish time | – | 122 | – | ns |
| T(hsync) | PCM_SYNC hold time | – | 366 | – | ns |
| T(sudin) | PCM_IN establish time | 60 | – | – | ns |
| T(hdin) | PCM_IN hold time | 60 | – | – | ns |
| T(pdout) | From PCM_CLK rising edge to PCM_OUT valid time | – | – | 60 | ns |
| T(zdout) | From PCM_CLK falling edge to PCM_OUT high impendence delay time | – | – | 60 | ns |

## 3.6.2 PCM interface application

L600 only support the host mode, PCM_SYNC,PCM_CLK is the output pin，PCM_SYN as the synchronizing output 8kHz sync signal. PCM Data support 8bit or 16bit data.



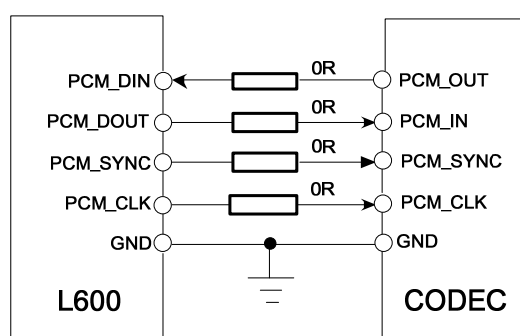Figure 3-10 PCM application circuit（L600 in host mode）

*Note:1. L600 PCM port DC character is base on 1.8 voltage, please pay attention the voltage matching.*

*2. If your design need this function, you should add the crystal for PCM clock. About the crystal type please contact our market.*

*3. L600 default design base on NAU8814 as the codec chip, the detail design please refer to 《L600 reference design》.*

# 3.7 USB2.0 interface

## 3.7.1 USB interface pin definition

L600 module include a high-speed USB 2.0 compliant interface with maximum 480 Mb/s data rate according to USB 2.0 specification, representing the main interface for transferring high speed data with a host application processor. The module itself acts as a USB device and can be connected to any USB host equipped with compatible drivers.

The USB is the most suitable interface for transferring high speed data between module and a host processor, available for AT commands, data communication, FW upgrade, below table is the module USB pin definition:

Table 3-13 USB interface pin definition

| Pin No. | Signal name | I/O type | DC characteristic (V) | | |
|---------|-------------|----------|------|------|------|
| | | | Min. | Typ. | Max. |
| 6 | USB_DM | USB2.0 date D- | – | – | – |
| 7 | USB_DP | USB2.0 data D+ | – | – | – |

## 3.7.2 USB Interface application

USB bus is mainly used for data transmission, software upgrading, module testing. Work in the high-speed mode of the USB line, if you need ESD design, ESD protection device must meet the junction capacitance value <5pf, otherwise the larger junction capacitance will cause waveform distortion, the impact of bus communication. Differential impedance of differential data line in 90ohm + 10%. In your application must add a 47Kohm resistor between USB_VBUS to ground.
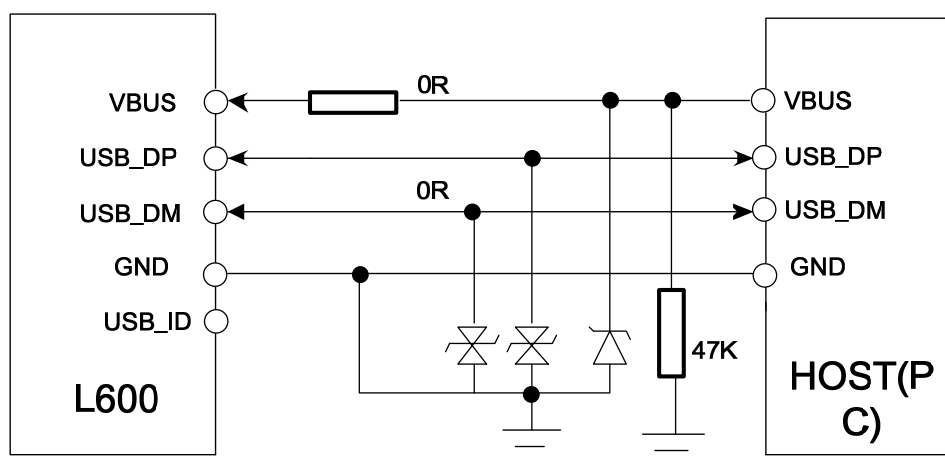
Figure 3-11 USB application

# 3.8 UART Interface

## 3.8.1 Pin description

L600 module provides a flexible 7-wire UART (universal asynchronous serial transmission) interface. UART as a full asynchronous communication interface, Support the standard modem handshake signal control, Comply with the RS - 232 interface protocols. And also support four wire serial bus interface or the 2-wire serial bus interface mode, and the module can be through the UART interface for serial communication with the outside (DET) and the AT command input, etc. L600 module is a DCE (Data Communication Equipment) and client PC is a DTE (Data Terminal Equipment).AT commands are entered and serial communication is performed through UART interface. The pin signal is defined as shown in below table.

Table 3-14 UART pin definition

| Pin No. | Pin | I/O type | Descriptions |
|---------|-----|----------|--------------|
| 54 | UART_TX | DO | UART data transmission |
| 53 | UART_RX | DI | UART data receive |
| 55 | UART_RI | DO | Ring Indicator. |
| 51 | UART_RTS | DO | UART DET request to send |
| 57 | UART_DTR | DI | DTE get ready. |
| 52 | UART_CTS | DI | UART Clear to Send. |
| 56 | UART_DCD | DO | UART Carrier detects. |

## 3.8.2 UART interface application

L600 UART is COMS 1.8V level, Complete serial port with RS-232 functionality conforming to the ITU-T V.24 Recommendation, with CMOS compatible signal levels (0 V for low data bit or ON state and 1.8 V for high data bit or OFF state), if the AP voltage level is not the 1.8V should add a voltage transfer module in your application. Below is RS-232 voltage transfer module application diagram

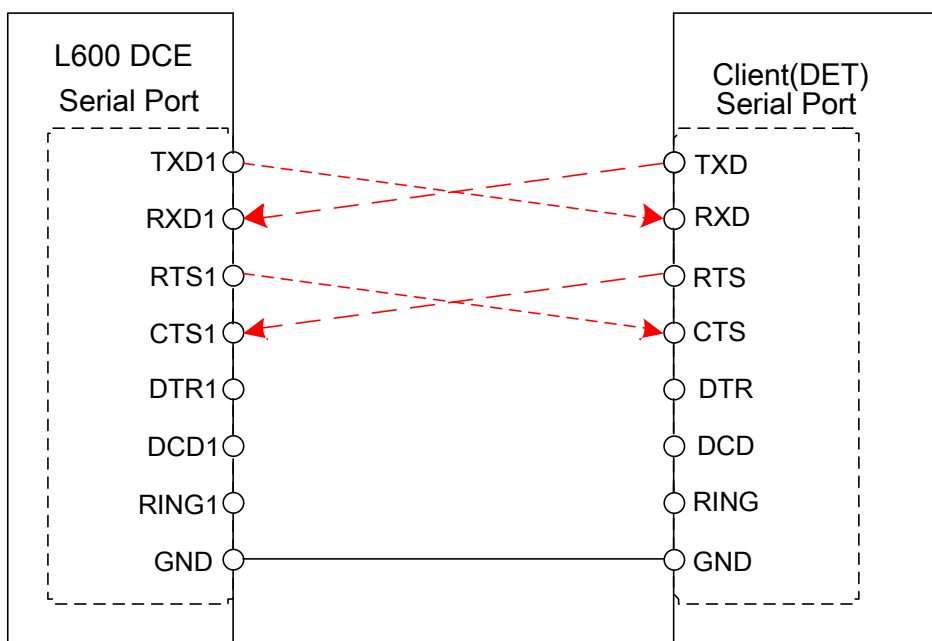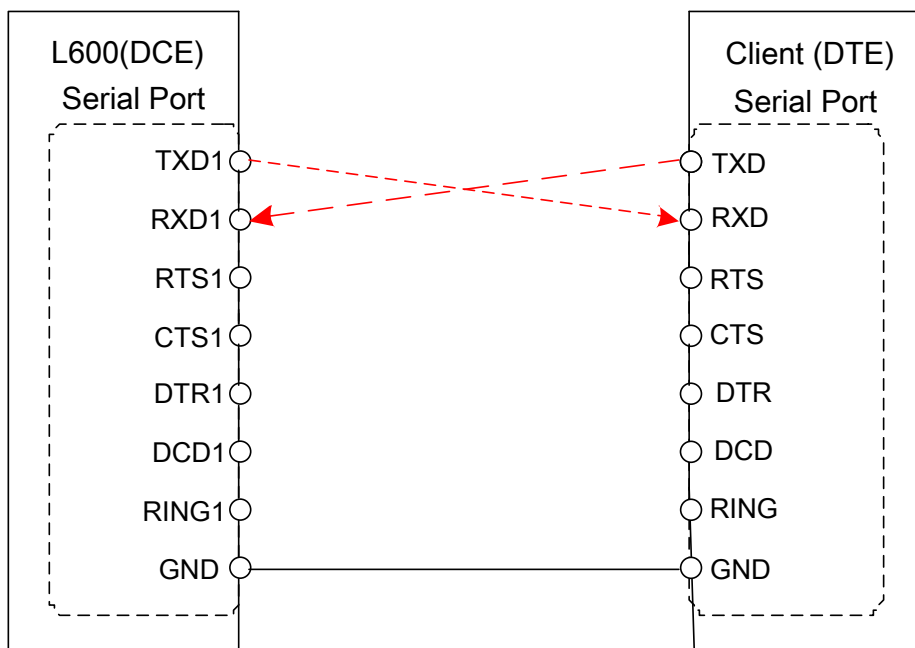Figure 3-12 UART 4 Line connection mode

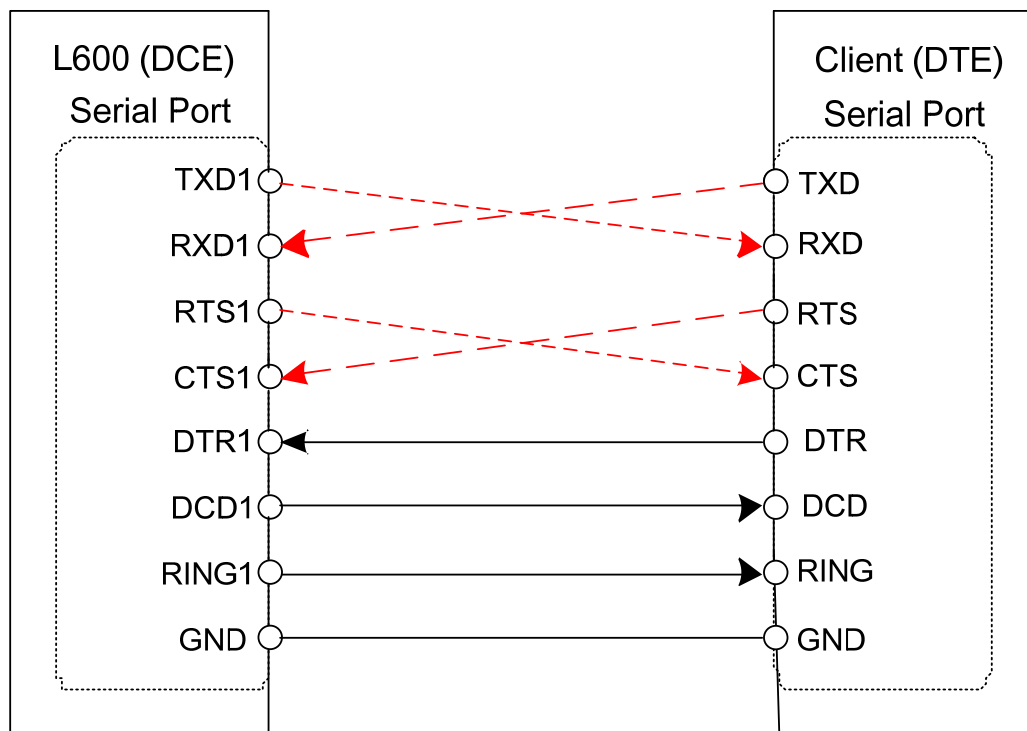Figure 3-13 UART 2 Line connection mode

Figure 3-14 UART Full mode

The L600 UART is 1.8V interface. A level shifter should be used if user's application is equipped with a 3.3V UART interface. The level shifter TXB0108RGYR provided by Texas Instruments is recommended. The reference design of the TXB0108RGYR is in the following figures. About the application as below:

Figures 3-16 Voltage transfer Reference Circuit
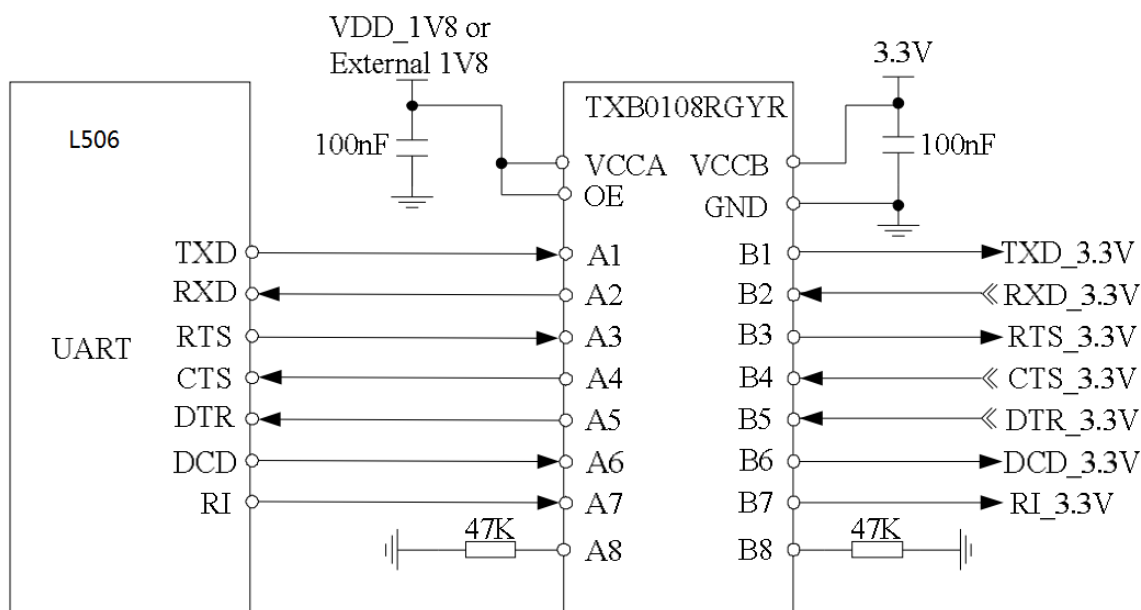
# 3.9 Power on/off and reset interface

## 3.9.1 Pin definition

L600 can be powered on by pulling PWRKEY pin down to ground. This pin is already internal pulled up to 1.8V in module (because the internal resistance divided voltage, so in actual measure voltage is approximately 800mV), so external pull-up resistor is not necessary. Placing a100nF capacitor and an ESD protection diode close to the PWRKEY pin is strongly recommended. Please refer to the following figure for recommended reference circuit.

Table 3-15 power on/off and reset key define

| Pin No. | Net name | I/O Typ. | descriptions |
|---|---|---|---|
| 36 | PHONE_ON_N(PWRKEY) | DI | L600 power on/off pin (internal pull-up to 1.8V) |
| 37 | RESET_N | DI | L600 RESET pin (internal pull-up to 1.8V) |

## 3.9.2 Power on sequence

Table 3-16 power on timing chart.

| Ton | Power on low level pulse | 100 | 500 | -- | ms |
|---|---|---|---|---|---|
| Ton(status) | Power on time (According to the STATUS pin judgment) | 15 | -- | 25 | s |
| Ton(uart) | Power on time (according the UART pin judgement) | 10 | -- | 20 | s |
| $V_{IH}$ | Input high level voltage of PWRKEY pin | 1.17 | 1.8 | 2.1 | V |
| $V_{IL}$ | Input low level voltage of PWRKEY pin | -0.3 | 0 | 0.3 | V |
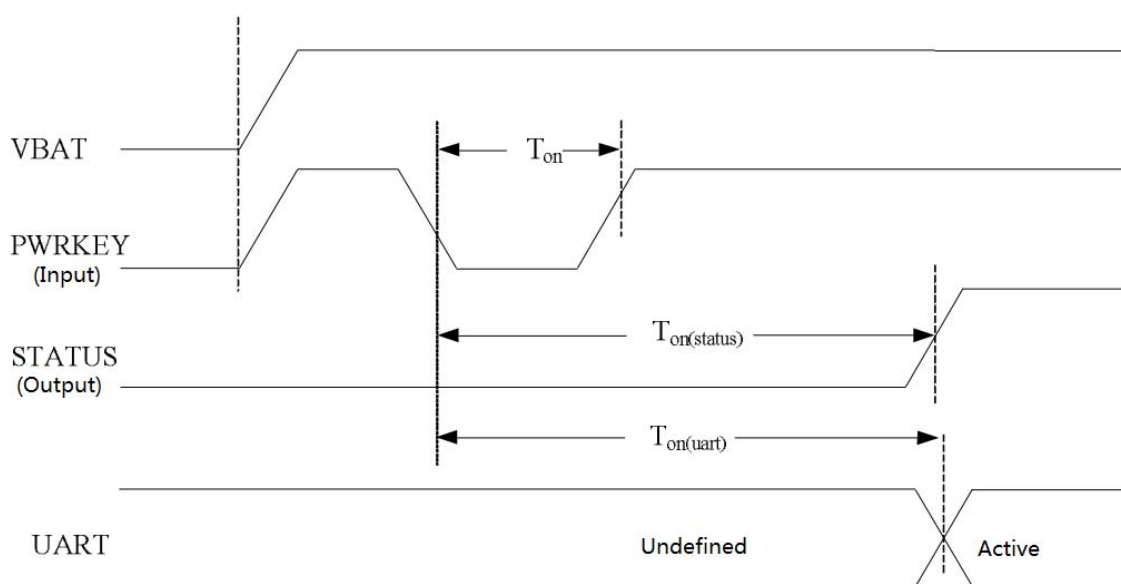
Figures 3-17 Power on Timing sequence

*Note: the STATUS pin can be used to identify whether has been power on, when the module has access to electricity and initialization is completed, the STATUS output high level, or has maintained low level.*

### 3.9.3 Power off sequence

The following methods can be used to power down. These procedures will make module disconnect from the network and allow the software to enter a safe state, and then save data before completely powering the module off.

- Method 1: Power off L600 by pulling the PWRKEY pin down
- Method 2: Power off L600 by AT command "AT+CPOF"
- Method 3: over-voltage or under-voltage automatic power down.
- Method 4: over-temperature or under-temperature automatic power down.

Note: 1. About the AT command "AT+CPOF" detail please refer document [1].

2. *Over-voltage or under-voltage may cause automatic power down.*

3. *Over-temperature or under-temperature may cause automatic power down.*

Table 3-17 Power off timing chart.

| Toff | The time of active low level pulse on PWRKEY pin to power off module | 2.5 | -- | -- | s |
|------|------|------|------|------|------|
| Toff(status) | The time from power-off issue to STATUS pin output low level (indicating power off) | 6 | -- | -- | s |

| | | | | | |
|---|---|---|---|---|---|
| Toff(uart) | The time from power-off issue to UART port off | 6 | -- | -- | s |
| Toff-on | The buffer time from power-off issue to power-on issue | 0 | -- | -- | V |
| V$_{IH}$ | Input high level voltage of PWRKEY pin | 1.17 | 1.8 | 2.1 | V |
| V$_{IL}$ | Input low level voltage of PWRKEY pin | -0.3 | 0 | 0.3 | V |

User can power off the L600 by pulling PWRKEY down to ground for a specific time. The
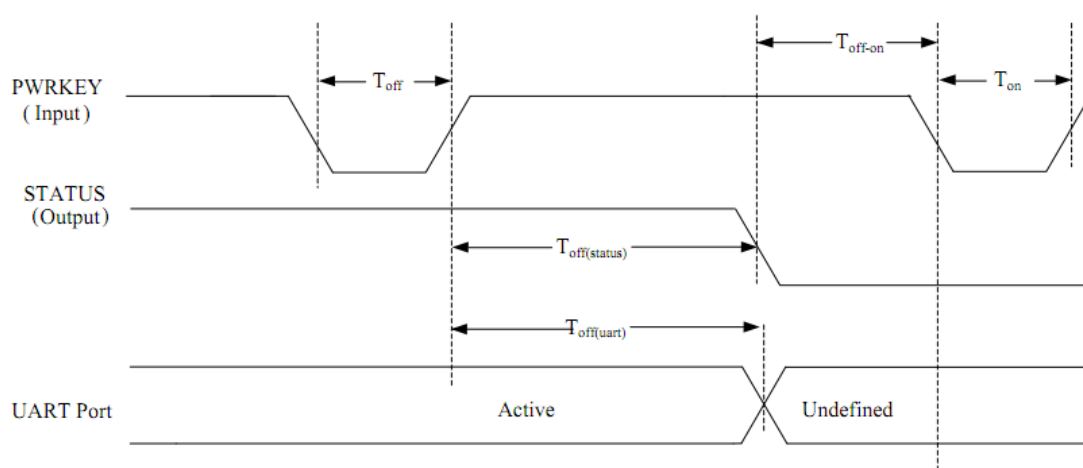


Figures 3-18 Power off Timing sequence

*Note: the STATUS pin can be used to identify whether has been power on, when the module has access to electricity and initialization is completed, the STATUS output high level, or has maintained low level.*

### 3.9.4 Reset sequence

L600 also have a RESET pin to reset module. This function is used as an emergency reset only when AT command "AT+CPOF" and the PWRKEY pin has no effect. User can pull RESET pin to ground, and then pull down the PWRKEY, the module will reset. This pin is already pulled up with a 40KΩ resistor to 1.8V in module, so external pull-up resistor is not necessary. Placing a100nF capacitor and an ESD protection diode close to the RESET pin is strongly recommended. Please refer to the following figure for recommended reference circuit, you can pull-down this pin to ground and hold about 200 MS and then release will force the module enter reset state.

Table 3-18 Reset pin electrical properties

| Symbol | Net name | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Treset | Reset pin low level hold time | 50 | 100 | 500 | ms |
| V$_{IH}$ | Reset pin input high level | 1.17 | 1.8 | 2.1 | V |

| $V_{IL}$ | Reset pin input low level | −0.3 | 0 | 0.3 | V |

*Note: it is recommended that only in an emergency, such as module without response, use the RESET pin. In addition, under the module power off status the RESET pin is invalid.*

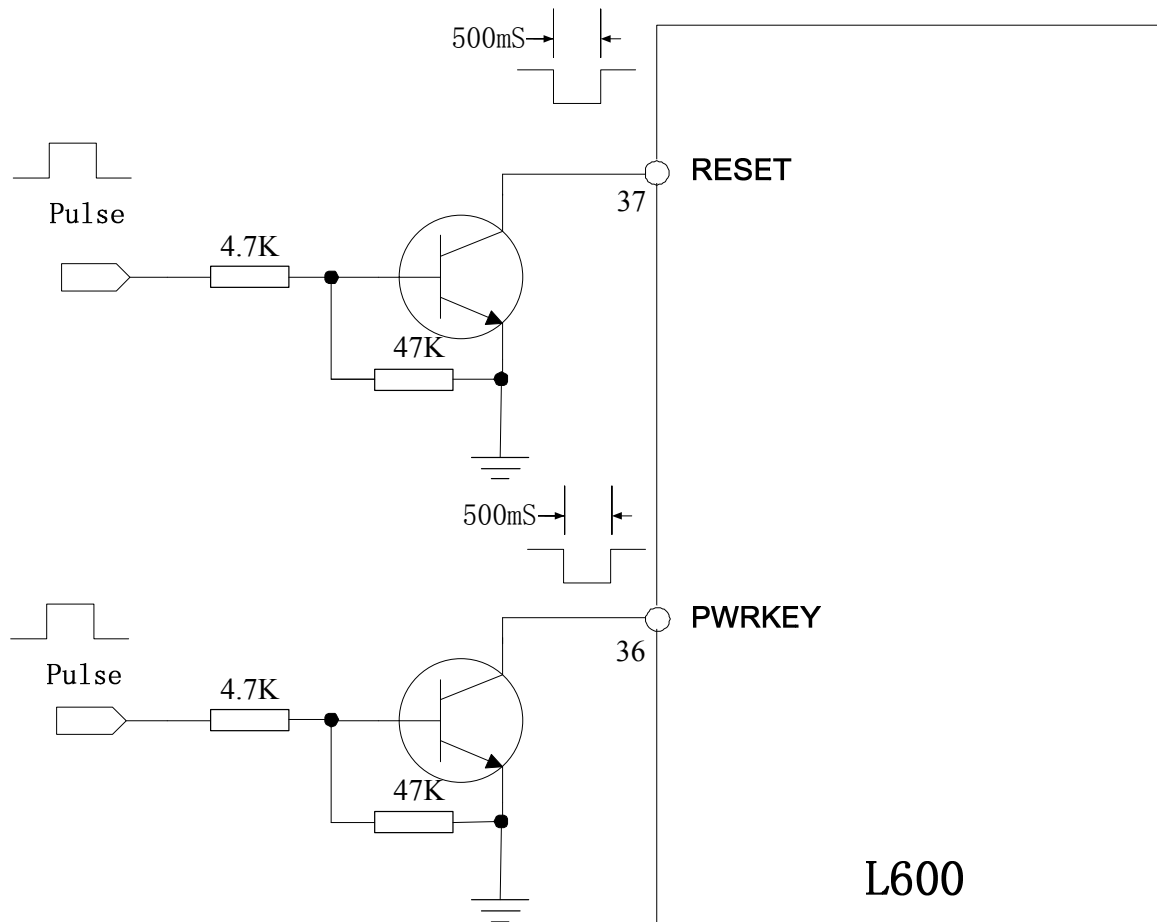### 3.9.5 Power on/off and reset interface application



Figure 3-19: Reference power on/off reset circuit

Another way to control the PWRKEY pin is directly using a push button switch. Need to set a button near the TVS to ESD protection. The image below for reference circuit:
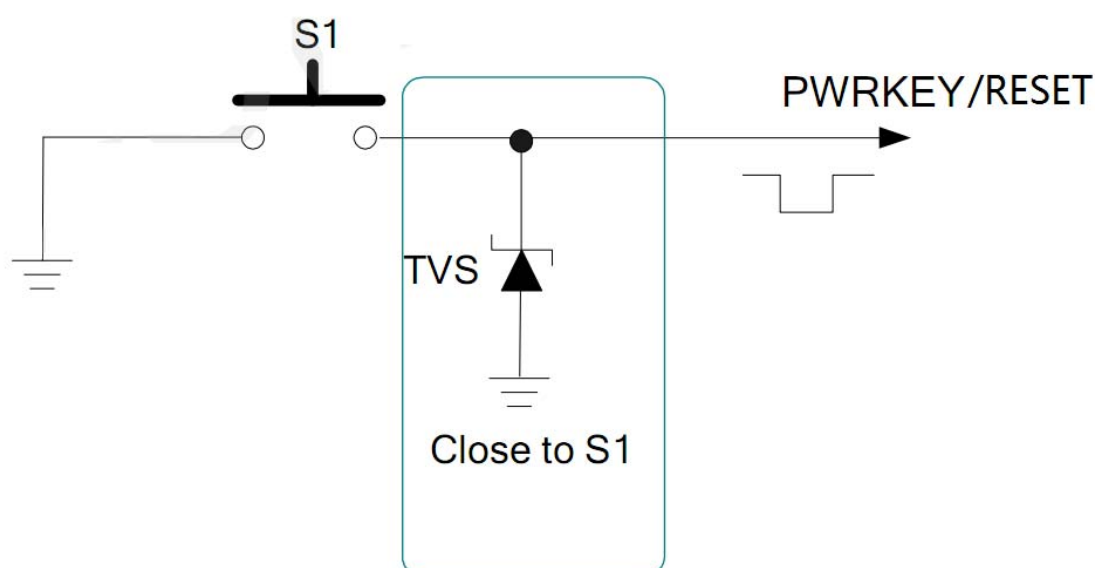
Figure 3-20: power on/off and reset recommended circuit (physical buttons)

# 3.10 Interactive interface

## 3.10.1 Pin definition

Table 3-19 list the interface is mainly with the application processor interactive interface, including query, wake up four types, status indication, flight mode interface.

Table 3-19 Interactive interface

| Pin No. | Signal | I/O type | Descriptions |
|---------|--------|----------|--------------|
| 46 | GPIO_2/WAKEUP_IN | DI | Default: GPIO<br>Optional: Input pin as wake up interrupt signal to module from host. |
| 47 | GPIO_1/WAKEUP_OUT | DO | Default: GPIO<br>Optional: Output pin as the module wake up the AP |
| 59 | STATUS | DO | AP inquire the module status |
| 48 | FLGHTMODE | DI | Pull up to 1.8V made the system enter in flight mode, at this mode will tune off all the wireless function |
| 42 | GPIO_0 | DO | General GPIO module output (used for keyboard backlighting, etc.) |
| 28 | GPIO_3 | I/O | GPIO |

## 3.10.2 interactive interface application

L600 provides three shook hands with application processor communication signals. Application processor can query whether the module boot normal work through STATUS. Through the WAKEUP_OUT query module is in sleep mode, and sleep in the module, through WAKEUP_IN wake module. Similarly, when application processor in the sleep state, the L600 modules can through WAKEUP_OUT wake application processor.

- STATUS：Module sleep instructions, high level indicator to sleep, low level instructions for the awakened state;
- WAKEUP_IN： The host can lower the signal awakens the module，If, low level has maintained, module can't sleep.
- WAKEUP_OUT: when L600 need to communicate with the AP, module can be set this pin for low level to awaken application processor.
- FLGHTMODE：Through the external output high level module into flight mode;

FLIGHTMODE pin can be used to control module to enter or exit the flight mode. In flight mode, L600 internal radio frequency circuit is closed. FLIGHTMODE reference circuit as shown in the figure below:
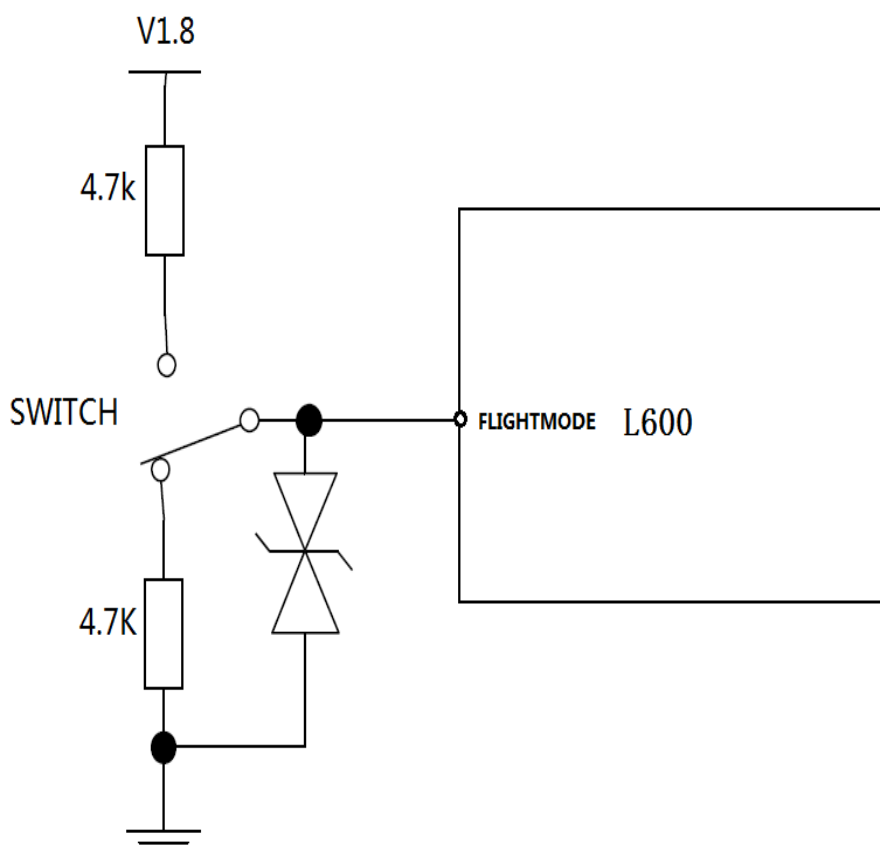


**Figure 3-21:** Flight mode recommended circuit (physical buttons)

# 3.11 Net Light interface

## 3.11.1 Pin define

Table 3-20 LED pin definitions

| Pin No. | Net name | I/O type | description |
|---------|----------|----------|-------------|
| 39 | NETLIGHT | DO | Module net state identify control LED port |

## 3.11.2 Net light application

The L600 module has 1 pins for controlling the LED display, which can be used as an indicator of network connection status. Different network states are represented by the mode of the flashing light. This pin is an GPIO，with An external NPN Transistor，External connect VBAT can directly drive LED. Drive current capacity varies according to external NPN model，recommend use DTC143ZEBTL，Drive current biggest can reach 100 mA, below is the reference circuit.
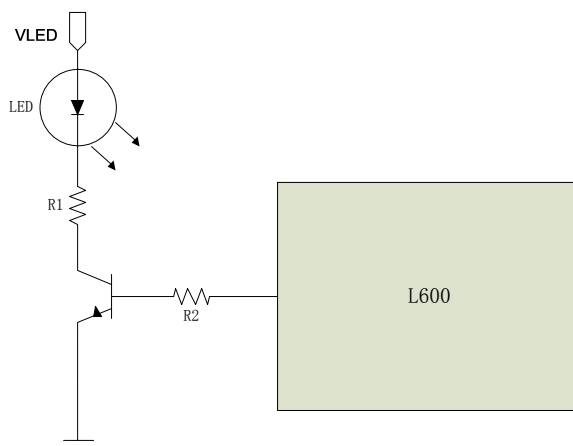


**Figure 3-22** Status indicator reference circuit

Note: R1, R2 value according to the voltage VLED and LED working current.

Table 3-21 NETLIGHT status

| Net Status | Module working status |
|------------|----------------------|
| Always on | Searching Network/Call Connect |
| 200ms ON, 200ms OFF | Data Transmit |
| 800ms ON, 800ms OFF | Registered network |
| OFF | Power off / Sleep |

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

# 3.12 System boot configuration and download

## 3.12.1 Pin definition

L600 can configure BOOT_CONFIG (Boot Configuration) pin to Configuration module power-on mode and the forced entry USB download mode.

Table 3-23 Boot configuration and force USB download

| Pin No. | Net name | | Function description | note |
|---------|----------|--|----------------------|------|
| 23 | GPIO(System on) | BOOT_CFG0(before system on) | Pull up this pin change boot configuration register value | Multiplex pin |
| 58 | GPIO(System on) | FOCE_USB_BOOT (before system on) | Pull up this pin change boot configuration register value | Multiplex pin |

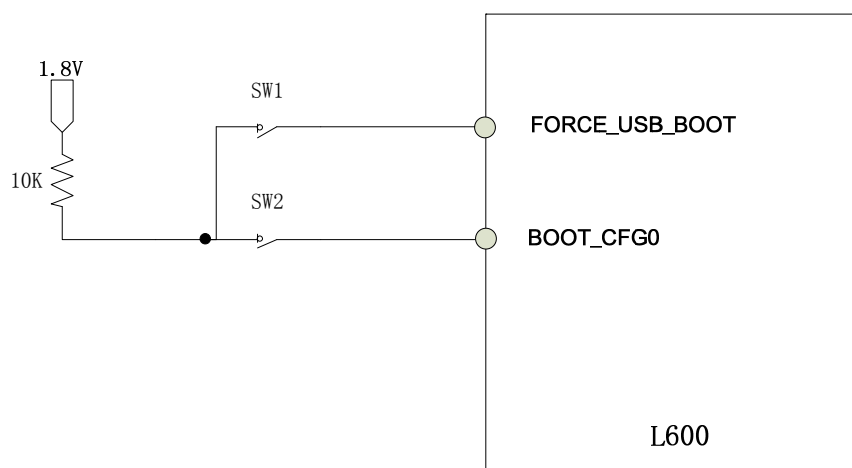## 3.12.2 Boot configuration and force USB interface application



Figure 3-25 boot configuration and force USB download recommended circuit

# 3.13 Analog and Digital conversion (ADC) interface

L600 integrated two analog-to-digital conversion interface, specific parameters are as follows:

Table 3-25 ADC1, ADC2 characters

| characters | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| ADC resolution | -- | 15 | -- | Bits |
| Transfer time | -- | 442 | -- | ms |
| Input voltage range | 0.3 | -- | VBAT | V |
| Input resistance | 1 | -- | -- | MΩ |

*Note: 1. use "AT + CADC" and "AT + CADC2" can read ADC1 and ADC2 voltage on the pin. More information please refer to the document [1].*

*2. The need for special software version to support access to the ADC.*

# 3.14 I2C interface

## 3.14.1 I2C pin definition

I2C is used to communicate with peripheral equipment and can be operated as either a transmitter or receiver, depending on the device function. Both SDA and SCL are bidirectional lines connected with I2C interface. Its operation voltage is 1.8V. High speed mode transmission rate can reach 400 KBPS, Because L600 haven't internal pulled up to the I2C interface, so in your design need pull up. Below figure is the reference design:
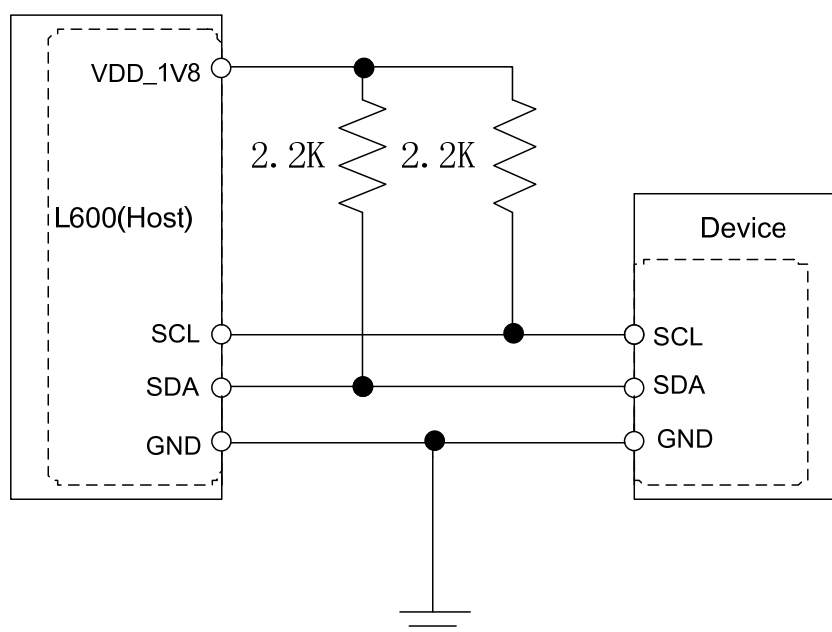


Figure 3-28 I2C reference design

*Note: 1. L600 I2C only support host mode.*

*2. Only special software version support inquire the I2C.*

# 3.15 Antenna interface

## 3.15.1 RF signal PCB layout guide

a) Trace layout and dimensions including specific designs for each type:

1) Customer's antenna should be located in the host board and connected to module's antenna pad through micro-strip line or other types of RF trace and the trace impedance must be controlled in 50Ω. RF antenna interface type can be SMA , RF connector and so on. And isolation is required greater than 35 dB.

2) In layout design, antenna RF transmission line must ensure the characteristic impedance = 50 ohm. The characteristic impedance depend on substrate board, line width and the distance from the ground plane.

3) For convenience of antenna tuning and certification test, should increase RF connectors and the antenna matching circuit, below is a recommended circuit:
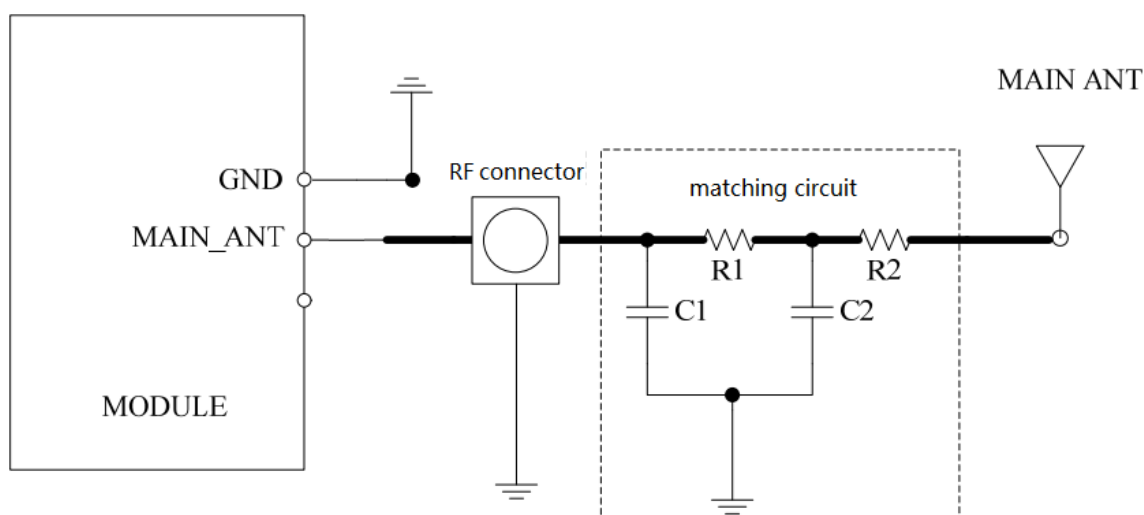


**Figure 3-29** Main antenna matching circuit diagram（**MAIN_ANT**）

In this figure, the components R1, C1, C2 and R2 is used for antenna matching, the value of components can only be got after the antenna tuning, usually, they are provided by antenna vendor. By default, the R1, R2 are 0 Ohm resistors, and the C1, C2 are reserved for tuning.
The RF test connector in the figure is used for the conducted RF performance test, and should be placed as close as to the module's antenna pin. The traces impedance between components must be controlled in 50ohm. And antenna gain is required not less than 3 dBi.

4) As shown in figure 3-20 is the layout of antenna feed point of reference for clearance area.
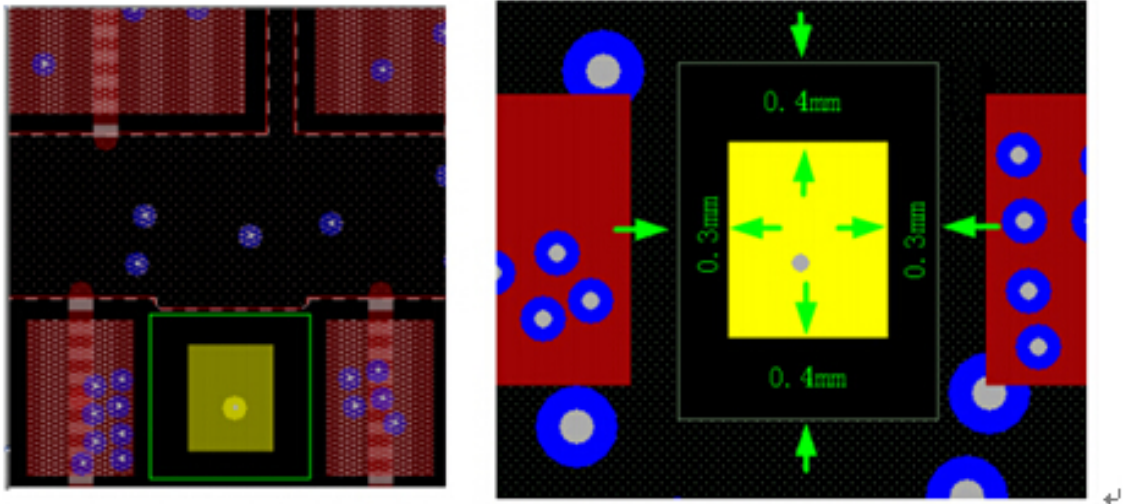
Figure 3-33 antenna feed point

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

The antenna feed point is defined as shown in below table：

Table 3-26 antenna pin definition

| Pin No. | Signal | I/O Typ. | Description |
|---------|--------|----------|-------------|
| 18 | MAIN_ANT | AI/AO | Module main antenna |

c) we recommends that the total insertion loss between the antenna pad and antenna should meet the following requirements and test procedures for design verification:

- LTE (F<1GHz) <0.5dB
- LTE (1GHz<F<2GHz) <0.9dB
- LTE (2GHz<F) <1.2dB

# 4 Product characteristics

## 4.1 Absolute parameters

The following table shows the state of the absolute maximum work in abnormal situation. Exceed the limit value will likely result in permanent damage to the module.

Table 4-1 L600 absolute parameters

| Parameter | Min. | Max. | Unit |
|---|---|---|---|
| VBAT absolute voltage parameter | -0.5 | 6.0 | V |
| USB_VBUS absolute voltage parameter | -0.5 | 5.25 | V |
| I/O absolute voltage parameter: PWRKEY, RESET, SPI, GPIO, I2C, PCM, UART, USIM_DET | -0.3 | 2.1 | V |
| I/O absolute voltage parameter: USIM | -0.3 | 3.05 | V |

## 4.2 Operation condition

### 4.2.1 Operation voltage

This product is a DC input voltage range of 3.4 V to 4.2 V, the typical value of 3.8 V, as shown in below table.

Table 4-2 Input DC voltage

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| VBAT Voltage | 3.4 | 3.8 | 4.2 | V |
| USB_VBUS Votage | 2.0 | 5.0 | 5.25 | V |

About L600 dc electric property, please refer to part 3.3 digital I/O characteristics.

### 4.2.2 Work mode(TBD)

Table 4-3 work mode

| Mode | | Description |
|---|---|---|
| Normal operation mode | (LTE)Sleep | In this case, the current consumption of module will be reduced to the minimal level. In sleep mode, the module can still receive paging message and SMS. |
| | (LTE) Idle | Software is active. Module is registered to the GSM/WCDMA/TD-SCDMA/EVDO/LTE network, and the |

| | | |
|---|---|---|
| | | module is ready to communicate. |
| | (LTE) taking | 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. |
| | (LTE) Standby | Module is ready for GPRS/EDGE/WCDMA/TD-SCDMA/EVDO/LTE data transfer, but no data is currently sent or received. In this case, power consumption depends on network settings and EDGE/HSPA+ /LTE configuration. |
| | (LTE) Data transfer | There is GPRS/EDGE/WCDMA/TD-SCDMA/EVDO/LTE data transfer in progress. In this case, power consumption is related to network settings (e.g. power control level); uplink/downlink data rates and GPRS configuration (e.g. used multi-slot settings). |
| Minimum 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 or the USIM card will not be accessible, or both RF part and USIM card will be closed, and the serial port is still accessible. The power consumption in this mode is lower than normal mode. |
| Flight mode | | Use the "AT + CFUN = 7" command or lower FLIGHTMODE pins, the module can be configured to flight mode under without removing the power supply condition. In this case, the RF part does not work, but still can use the serial port and USB, the power consumption is lower than normal working mode. |
| Power off | | Through the "AT + CPOF" command or lower PWRKEY pin can power off L600. At this mode, the module of internal power supply will be closed, and the system is stop running also. The UART and USB are unavailable. |
| Sleep mode | | In sleep mode, the module power consumption to a minimum, but the module is still able to receive paging information and SMS. |

## 4.2.3 current consumption(TBD)

The power consumption in suspended mode and without USB connection is listed in the table below.

Table 4-4 working current consumption (VBAT=3.8V)

| Power off | |
|---|---|
| Power off current | 8uA |
| **LTE Sleep/Idle** | |
| LTE supply current | Sleep mode typical: TBD<br>Idle mode typical: TBD |
| **LTE Data transmission** | |
| FDD B2 | @1.4Mbps typical: TBD |
| FDD B4 | @1.4Mbps typical: TBD |
| FDD B12 | @1.4Mbps typical: TBD |
| FDD B13 | @1.4Mbps typical: TBD |
| FDD B8 | @180Kbps typical: TBD |
| FDD B20 | @180Kbps typical: TBD |

# 4.3 Working and storage temperature

The operating temperature and storage temperature of L600 is listed in the following table.

Table 4-5 Operating temperature

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Extended operation temperature* | −40 | 25 | 85 | ℃ |
| Storage temperature | −45 | 25 | 90 | ℃ |

# 4.4 ESD performance

L600 is electrostatic sensitive device, therefore, the user in the production, assembly and operation of the module must pay attention to the electrostatic protection. L600 ESD performance parameters in the following table:

Table 4-6 ESD performance parameters (temperature 25 ℃, humidity: 45%)

| Net | contact | air |
|---|---|---|
| VBAT GND | ±5KV | ±10KV |
| Antenna port | ±4KV | ±8KV |
| UART | ±2KV | ±4KV |

| USB | ±3KV | ±6KV | |
|---|---|---|---|
| Other PADS | ±2KV | ±4KV | |

# 5 Design guideline

This chapter provides a general design of the products instruction, the user can refer to design guidance for design, make products to achieve better performance.

## 5.1 General design rules and requirements

Users in the design of this product is peripheral circuit, the first to ensure the external power supply circuit can provide enough power supply capacity, And the requirements for high speed signal lines USB control 90 ohm + / - 10% difference impedance. For general signal interface, require the user to us in strict accordance with the requirements of design, in line with the interface signal level matching, in case the level of damage to the module. This product its own radio frequency index is good, customers need to design in accordance with the requirements the mainboard side antenna circuit and corresponding impedance control, otherwise it will affect the whole RF index.

## 5.2 Reference circuit

Request system board VPH_PWR side power supply ability of power supply to achieve more than 1 A, meet the demand of modules, peak current, and the system side the power of the average current will reach more than 0.9 A. System board side power supply cord shall ensure enough line width, and wants to form a good return with the ground plane, moreover should increase in the power supply circuit design the method of micro level energy storage capacitor, guarantee the instantaneous power supply capacity, and the power supply ripple control within the 100 mv, the specific function of each functional module can be found in the corresponding description, overall reference circuit design please refer 《L600 reference design》.

## 5.3 RF part design guideline

## 5.3.1 Early antenna design considerations

● Pre-project evaluation

The selection of the antenna position must first ensure that the antenna and the base station are kept in the horizontal direction, this produces the highest efficiency; Secondly, try to avoid placing the switch in the power supply or data line, chip and other devices or chips that produce electromagnetic interference. At the same time, the position of the hand can be avoided, so as to prevent the human body to produce attenuation; But also to reduce the radiation and the structure of the realization of the need to take into account. So, At the beginning of the design need to structure, ID, circuit, antenna engineers together to evaluate the layout.

● Antenna matching circuit

If the module's radio frequency port and the antenna interface need to be transferred, the main board circuit design, The design of microstrip line or strip line between the module RF test base and the antenna interface between the microstrip line or the strip line by characteristic impedance 50 ohm, at the same time, reserved double L type matching circuit; If the antenna's RF connector can be directly stuck in the module's RF test base, can save the module of the RF port and the antenna interface between the transfer.

## 5.4 EMC and ESD design advice

Users should take full account of the EMC problem caused by signal integrity and power integrity in the design of the whole machine, In the module of the peripheral circuit layout, for power and signal lines, etc., to maintain the spacing of 2 times line width. Can effectively reduce the coupling between the signal, so that the signal has a clean, the return path. When the peripheral power supply circuit is designed, the decoupling capacitor should be placed close to the module power supply pin, High frequency high speed circuit and sensitive circuit should be far from the edge of PCB, and the layout of the layout as far as possible to reduce the interference between each other, and the sensitive signal is protected. The circuit or device that may interfere with the operation of the system board is designed.

This product is embedded in the system board side, design, need to pay attention to the ESD protection, the key input and output signal interface, such as (U) SIM card interface need to be placed close to the protection of ESD devices. In addition to the

motherboard side, the user is required to design the structure and PCB layout, ensure that the metal shield is fully grounded, and set up an unobstructed discharge passage for the electrostatic discharge.

## 5.5 PCB Recommended land pattern

Recommended at 64 of peripheral signal pads to the module with a length of 1.0 mm. Recommended PCB pads as shown in below.



Figure 5-1 RECOMMENDED LAND PATTERN (Unit: mm)

## 5.6 Products recommended upgrade

L600 default through the USB firmware updates, so products to facilitate the software update, when the design proposal to set aside the USB test points or interface to facilitate subsequent product of the firmware upgrade.

# 6 Manufacturers

## 6.1 Steel mesh design

●     At the bottom of the module pad thermal, can be reduced by way of steel mesh openings, reduce the risk of short circuit between the thermal and the module of the module Pin, have certain effect;

●     Module pad thermal welded steel mesh openings are recommended for reference. Figure 6-1 is recommended for steel mesh and size.
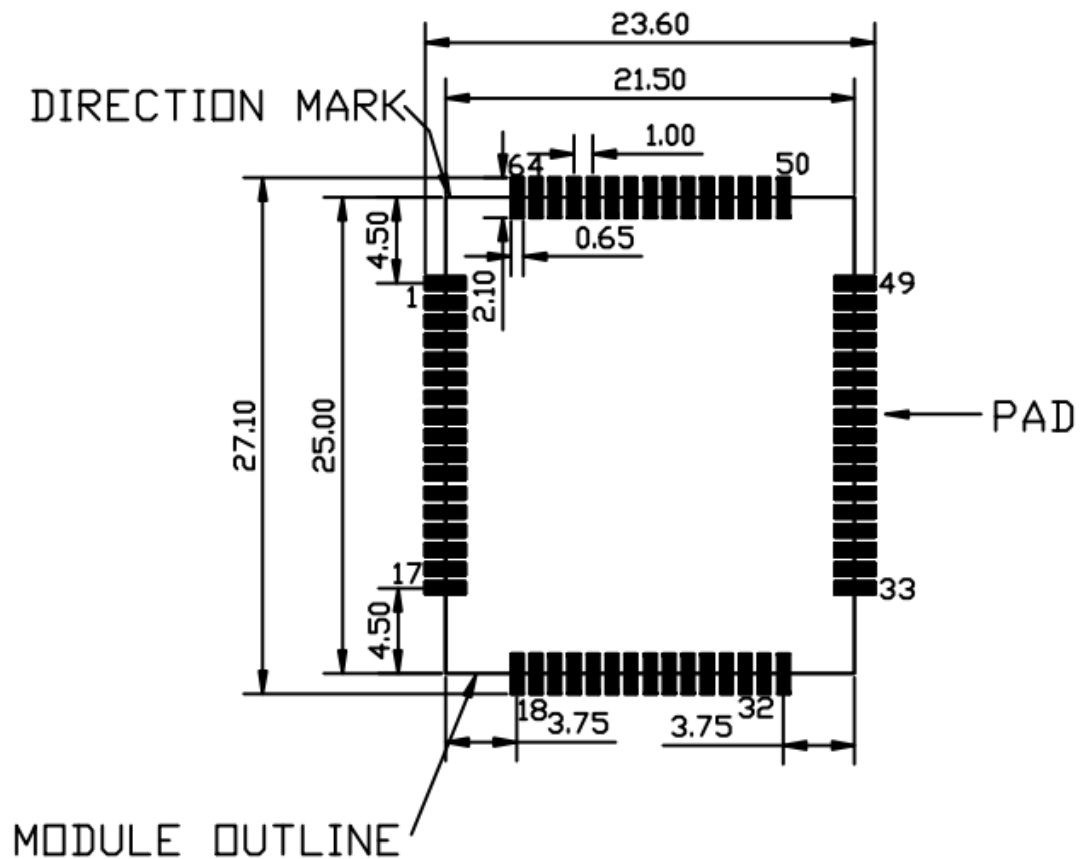


Figure 6-1 Steel mesh (unit mm)

*Note: The direction mark point only for identify the pin 1 position, should not embody in the steel mesh file.*

# 6.2 Temperature curve

The temperature curve of the welding quality and material status influence, please pay special attention. Temperature rise speed should not be too fast, from room temperature to 150, the temperature rise rate is less than 3s. At the same time in more than 217 degrees, please try to keep time no more than 70 seconds, at intermediate values of 55 seconds is appropriate. The thermal shock strength is too general will lead to part of the device failure, resulting in a decline in yield and maintenance difficulty. And please control the maximum temperature of no more than 245 degrees, partial material, such as crystal at high temperature easy to occur the package rupture, cause unable to play the problem, and then affect the function of the product, The temperature can be set using the curve shown in table 6-1.

Table 6-1 Temperature curve

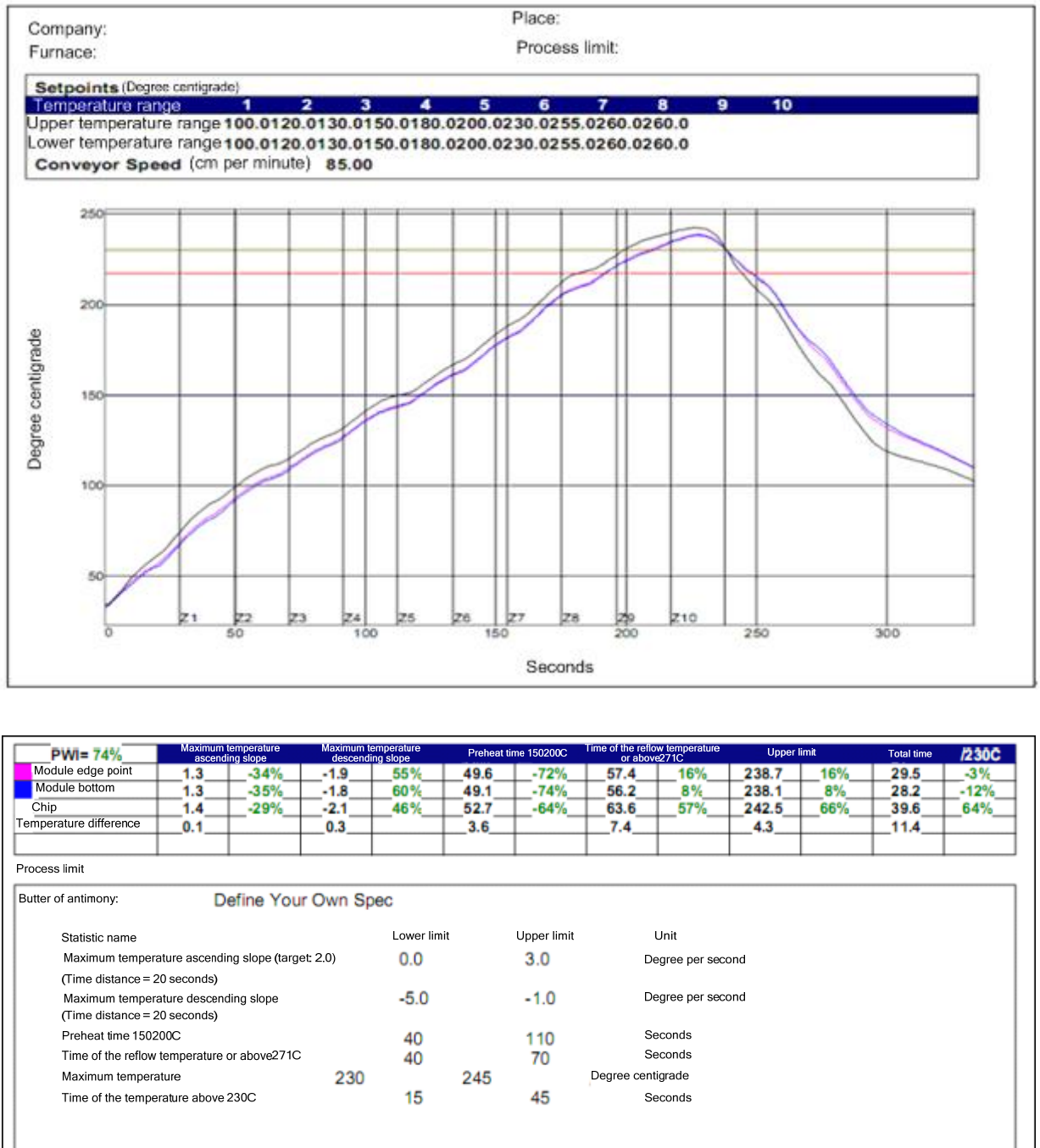| Lead-free process temperature curve | | |
|---|---|---|
| Stage | Temperature | time |
| Preheat | Temperature rise from room temperature to 150 | rate of temperature rising <3 / ℃ s |
| keep warm | 150℃~200℃ | 40~110 s |
| Welding | < 217℃ | 40~70 s |
| | < 230℃ | 15~45 s |
| | Peak temperature | MAX: 245℃ |
| | | MIN: 230℃ |

Figure 6-2　The reference temperature curve

# 6.3 The Moisture Sensitivity Level (MSL)

L600 module complies with the humidity level 3. At a temperature of <30 degrees and relative humidity of <60% of the environmental conditions, dry pack to perform J-STD-020C specification according to IPC / JEDEC standard. At a temperature of <40 degrees and a relative humidity of <90%

of the environmental conditions, in the case of unopened shelf life of at least six months. After unpacking, Table 6-2 shows the module shelf life at different times corresponding to the level of humidity.

Table6-2: Moisture sensitivity level and floor life

| The Moisture Sensitivity Level (MSL) | Floor Life(out of bag) at factory ambient≦+30 /60%RH |
|---|---|
| 1 | Unlimited at ≦+30 /85% |
| 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. |

After unpacking,<30 degrees in temperature and relative humidity <60% environmental conditions, 168 hours in the SMT patch. If not meet the above conditions need to be baked.

*NOTES: For product handling, storage, processing, IPC / JEDEC J-STD-020C must be followed*

# 6.4 Baking Requirements

Due to the humidity sensitive characteristics of the L600 module, the L600 is a vacuum packaging, which can be stored for 6 months without damage to the package, and the ambient temperature is less than 40 C and the relative humidity is less than 90%. To meet one of the following conditions, the process of reflow soldering should be performed before the full bake (if trays are used, please note whether the tray is heat-resistant.), or the module may cause permanent damage to the process.

1、Vacuum packing damage or leakage

2、The module is exposed in the air for 168 hours or more

3、The module is exposed in air for 168 hours, not meet the temperature <30 degrees and relative humidity of the environment conditions <60%

Table6-3: Baking requirements

| Baking temperature | Humidity | Baking time |
|---|---|---|
| 40°C±5°C | <5% | 192 Hours |
| 120°C±5°C | <5% | 4 Hours |

# 7 Package Storage information(TBD)

## 7.1 Package information(TBD)

### 7.1.1 Tape and reel information

### 7.1.1 Package information

## 7.2 Bagged storage conditions

L600 shipments in the form of vacuum sealing anti-static bag. Module of storage need to follow the following conditions: Environment below 40 Degrees Celsius temperature, air humidity is less than 90% of cases, the module can be in vacuum sealed bags for 12 months. Conditions set the storage environment Suggestions with reference to the following form.

Table 7-1 Storage conditions (less than 90% humidity of the air vacuum sealed packaging)

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Storage temperature | −45 | 25 | 90 | ℃ |

When on the vacuum bags, if meet the following conditions, the module can be directly for reflow soldering (furnace temperature setting reference 6.2 furnace temperature curve) or other high temperature process:

- Module temperature below 30 degrees c, the air humidity is less than 60%, factory within 72 hours to complete the SMT.
- The humidity is less than 10%.

If the module is in the following conditions, to be baked before SMT:

- When the environment temperature is 23 degrees Celsius (allow upper and lower volatility of 5 degrees Celsius), humidity index greater than 10%.
- When open vacuum bags, module temperature below 30 degrees Celsius, air humidity is less than 60%, but the factory have not finished the SMT within 72 hours.
- When open the vacuum bags, module storage air humidity is more than 10%.

# FCC Certification Requirements.

According to the definition of mobile and fixed device is described in Part 2.1091(b), this device is a mobile device.

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time- averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.

2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.

3.A label with the following statements must be attached to the host end product: This device contains FCC ID: 2AK9DL600A.

4.To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed:

❏LTE band 2 <=3dBi

❏LTE band 4 <=3dBi

❏LTE band 12 <=3dBi

5. This module must not transmit simultaneously with any other antenna or transmitter

6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

For this device, OEM integrators must be provided with labeling instructions of finished products. Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

A certified modular has the option to use a permanently affixed label, or an electronic label. For a

permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straight forward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module:"Contains Transmitter Module FCC ID:2AK9DL600A" or "Contains FCC ID: 2AK9DL600A" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.