# Lierda UB61 Series Hardware Design Manual

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State：Controlled Version

Company Address: Lierda Internet of Things Technology Park, No. 1326 Wenyi West Road, Hangzhou

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# Revision History

| Version | Date | Draft | Approved | Revision Content |
|---|---|---|---|---|
| Rev1.0 | 23-03-29 | CJH | YB | Initial Version |

# Safety Instructions

It is the user's responsibility to follow the relevant regulations of other countries on wireless communication modules and equipment, as well as their specific operating environment regulations. By following the safety principles below, you can ensure personal safety and help protect the product and work environment from potential damage. Our company is not responsible for related losses caused by customers' failure to follow these regulations.

| | |
|---|---|
|  | Road safety first! Do not use a handheld mobile terminal while driving unless it has a hands-free function. Please stop and call again! |
|  | Please turn off the mobile terminal device before boarding the plane. The wireless function of the mobile terminal is prohibited on the aircraft to prevent interference with the aircraft communication system. Ignoring this prompt may affect flight safety or even violate the law. |
|  | When in a hospital or health care facility, pay attention to whether there are restrictions on the use of mobile terminal equipment. RF interference can cause medical equipment to malfunction and it may be necessary to switch off the mobile terminal equipment. |
|  | The mobile terminal device does not guarantee a valid connection in all cases, eg no call charges or SIM invalidation on the mobile terminal device. When you encounter the above situations in an emergency, please remember to use the emergency call, and at the same time make sure that your device is powered on and in an area with sufficient signal strength. |
|  | Your mobile terminal equipment will receive and transmit radio frequency signals when it is turned on, and radio frequency interference will be generated when it is close to a TV, radio, computer or other electronic equipment. |
|  | Please keep the mobile terminal away from flammable gas. When you are close to gas stations, oil depots, chemical plants or explosive workplaces, please turn off the mobile terminal device. Operating electronic equipment in any potentially explosive atmosphere is a safety hazard. |

# Applicable Module Selection

| No. | Model Name | Support Frequency Band | Dimension | Description |
|---|---|---|---|---|
| 1 | L-WFMUB61-G5NI4 | 2.4 GHz ISM Band | 13x12.2mm | |

# Contents

# 1 Introduction

UB61 series is a low-cost Wi-Fi 6 module that supports 802.11b/g/n/ax@2.4G and BT5.2 (BR+EDR+BLE) functions. Its WLAN function supports USB 2.0 interface, and BT function supports PCM interface. The module supports 20MHz/40MHz bandwidth to ensure backward and network compatibility, and can be widely used in high-definition network cameras, OTT/IPTV/DVB/set-top boxes, smart TVs and other fields.


Figure 1.1 UB61 Series Model

# 2 Overview

## 2.1 General Specification

| | |
|---|---|
| Interface | Stamp hole |
| Wireless Standard | IEE 802.11 b/g/n/ax+BT5.2+BR+EDR |
| Dimension | 13 mm × 12.2 mm × 2.6 mm |
| Operating Temperature | 3.0V~3.6V，Typ 3.3V |
| Frequency Range | 2400~2483.5MHz(2.4 GHz ISM Band) |
| Operating Temperature | -20 ~ +80℃ |
| Storage Temperature | -40 ~ +85℃ |
| Communication Interface | USB 2.0+PCM |
| Bandwidth | Support 20/40MHz bandwidth |
| MAC | IEEE802.11 d/e/i/k/v/w |

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## 2.2 Features

1) Support IEEE 802.11b/g/n/ax@2.4G
2) Built-in BT5.2 dual-mode Bluetooth (BR+EDR+BLE)
3) Support STA、AP、Wi-Fi Direct mode
4) Support WEP/WPA/WPA2/WPA3-SAE Personal, MFP frequency
5) Support Wi-Fi/BT coexistence
6) Support USB2.0/PCM interface
7) Support MU-MIMO、OFDMA
8) Support Wi-Fi 6 TWT

## 2.3 Applications

- HD network camera, monitoring PTZ
- OTT/IPTV/DVB/Set-top Boxes
- Smart Home, Smart Home Appliances

## 2.4 Block Diagram

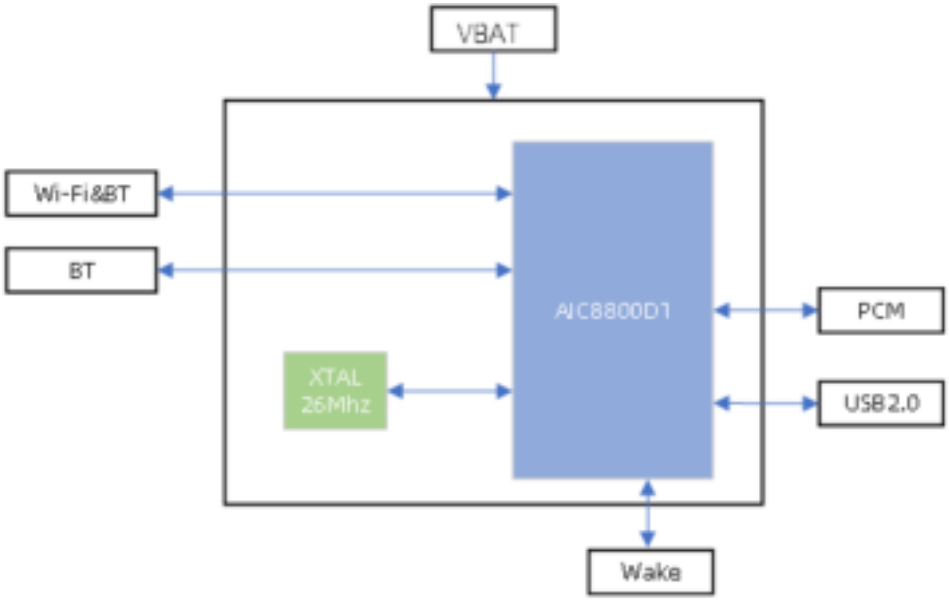



Figure 2.1 Block Diagram

## 2.5 Pin Assignments

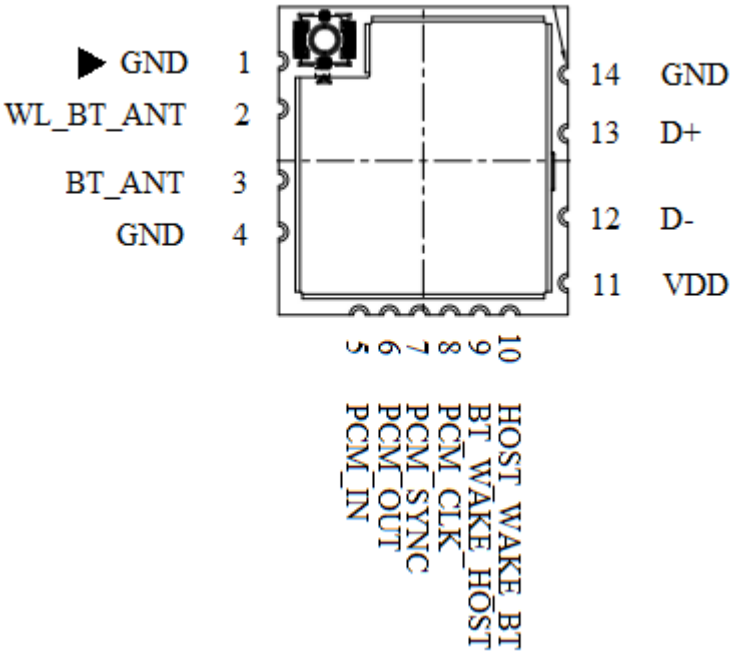



Figure 2.2 Pin Outline

## 2.6 Pin Definition

| No. | Name | I/O Type | Description |
|---|---|---|---|
| 1 | GND | G | Ground connections |
| 2 | WL_BT_ANT | RF | 2.4G Wi-Fi&BT ANT |
| 3 | BT_ANT | RF | BT ANT |
| 4 | GND | G | Ground connections |
| 5 | PCM_IN | I | PCM_IN |
| 6 | PCM_OUT | O | PCM_OUT |
| 7 | PCM_SYNC | I/O | PCM_SYNC |
| 8 | PCM_CLK | I/O | PCM_CLK |
| 9 | BT_WAKE_HOST | O | Bluetooth device to wake-up HOST (Active high, low level by default) |
| 10 | HOST_WAKE_BT | I | HOST to wake-up Bluetooth device (Active high) |
| 11 | VDD | P | 3.3V input (DC 3.3V，Typ) |
| 12 | D- | I/O | USB DATA - |
| 13 | D+ | I/O | USB DATA + |
| 14 | GND | G | Ground connections |

*“P”:POWER “I”:INPUT “O”:OUTPUT “G”:GND*

# 3 Working Characteristics

## 3.1 Power Supply Design

Proper decoupling is critical. As with all digital circuits, current is drawn in short pulses corresponding to clock edges. Especially when multiple I/O lines are switching simultaneously, transient current pulses on the power supply can be on the order of hundreds of milliamperes and last for a few nanoseconds, even if the average current draw is very small. These types of transient currents cannot be properly passed on high-impedance power supply lines without introducing appreciable noise into the supply voltage. To reduce this noise, decoupling capacitors are used to supplement the current during these short transients.

### 3.1.1 Decoupling Capacitor

Decoupling capacitors keep the current loops between the power supply, MCU, and ground as short as possible for decoupling of high-frequency transient noise. Therefore, all decoupling capacitors should be placed as close as possible to their respective power pins, ground pins, and PCB (printed circuit board) ground plane.

All external decoupling capacitors should have a temperature range that reflects the application environment. For example, suitable choices might be X5R or X7R ceramic capacitors whose capacitance varies ±15% over the temperature range of -55 to +85°C (standard temperature range) or -55 to +125°C (extended temperature range).

For the UB61 module, even if the module uses decoupling capacitors inside the module, due to the limited internal space of the module, the PDN (Power Delivery Network) of the module may not be able to meet the user's power integrity under actual use conditions Require, PDN analysis of UB61 module as shown in Figure 3.1.

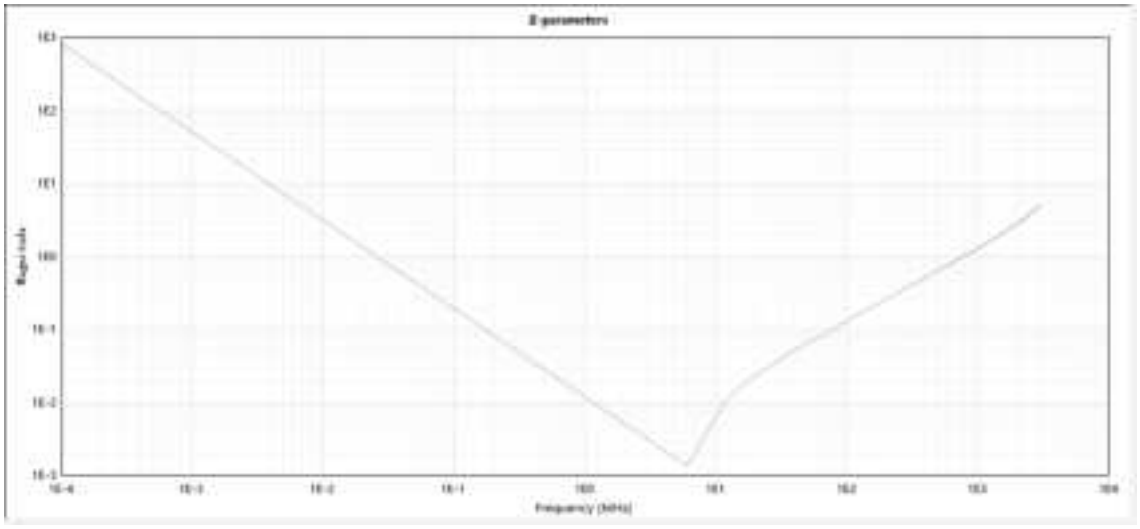


Figure 3.1 PDN analysis of UB61 module

As shown in the figure, when the power ripple and noise frequency is lower than 200kHz or higher than 80MHz, the PDN impedance is higher than 0.1Ω. At this time, it is difficult for the PDN impedance to suppress the magnitude of the voltage ripple and noise in the time domain.

Therefore, when using the UB61 module, an additional external decoupling capacitor may be required to meet the low enough PDN impedance in a wide frequency range (that is, the power supply noise amplitude can be accepted). It is recommended to add 22uF and 0.1uF . The large-capacity 22uF can reduce the PDN impedance of the low frequency band, and 0.1uF can reduce the PDN impedance of the high frequency band.

### 3.1.2 Power Requirements

An important consideration for all devices is the voltage requirements and dependencies between power supply pins. Regardless of the power supply configuration or topology, system designers need to ensure that these power supply requirements (such as voltage standards, power-up sequencing, etc.) are met. Failure to observe the following limits may result in equipment damage and/or increased current consumption. See 6 Electrical Performance and Reliability for additional details on absolute maximum ratings and related system voltage limitations.

# 4 Application Interface

## 4.1 USB

The USB signal is a differential high-speed signal, and attention should be paid to controlling the differential impedance and equal length during design, see Figure 4.1 USB Cable Characteristics.

The differential impedance of the USB differential line needs to be controlled at 90Ohm±15%; the common mode impedance needs to be controlled at 30Ohm±30%; and equal length should be ensured, Cable Skew is less than 100ps; the overall USB2.0 trace length also needs to be controlled, and Cable Delay is less than 26ns.

At the same time, the differential line attenuation of the USB differential line should not be too large, as shown in Figure 4.2 Maximum Allowable Cable Loss.

| Parameter | Symbol | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| VBUS Voltage drop for detachable cables | $V_{BUSD}$ | Section 7.2.2 | | 125 | mV |
| GND Voltage drop (for all cables) | $V_{GNDD}$ | Section 7.2.2 | | 125 | mV |
| Differential Cable Impedance (full-/high-speed) | Zo | (90 Ω ±15%); | 76.5 | 103.5 | Ω |
| Common mode cable impedance (full-/high-speed) | $Z_{CM}$ | (30 Ω ±30%); | 21.0 | 39.0 | Ω |
| Cable Delay (one way)<br>Full-/high-speed<br>Low-speed | <br>$T_{FSCBL}$<br>$T_{LSCBL}$ | Section 7.1.16 | | <br>26<br>18 | <br>ns<br>ns |
| Cable Skew | $T_{SKEW}$ | Section 7.1.3 | | 100 | ps |
| Unmated Contact Capacitance | $C_{UC}$ | Section 6.7 | | 2 | pF |
| Cable loss | | Specified by table and graph in Section 7.1.17 | | | |

Figure 4.1 USB Cable Characteristics

| Frequency (MHz) | Attenuation (maximum) dB/cable |
|---|---|
| 0.064 | 0.08 |
| 0.256 | 0.11 |
| 0.512 | 0.13 |
| 0.772 | 0.15 |
| 1.000 | 0.20 |
| 4.000 | 0.39 |
| 8.000 | 0.57 |
| 12.000 | 0.67 |
| 24.000 | 0.95 |
| 48.000 | 1.35 |
| 96.000 | 1.9 |
| 200.00 | 3.2 |
| 400.00 | 5.8 |

Figure 4.2 Maximum Allowable Cable Loss

The UB61 module has been designed with the above requirements in mind, so the user only needs to comply with the above regulations on the self-designed baseboard.

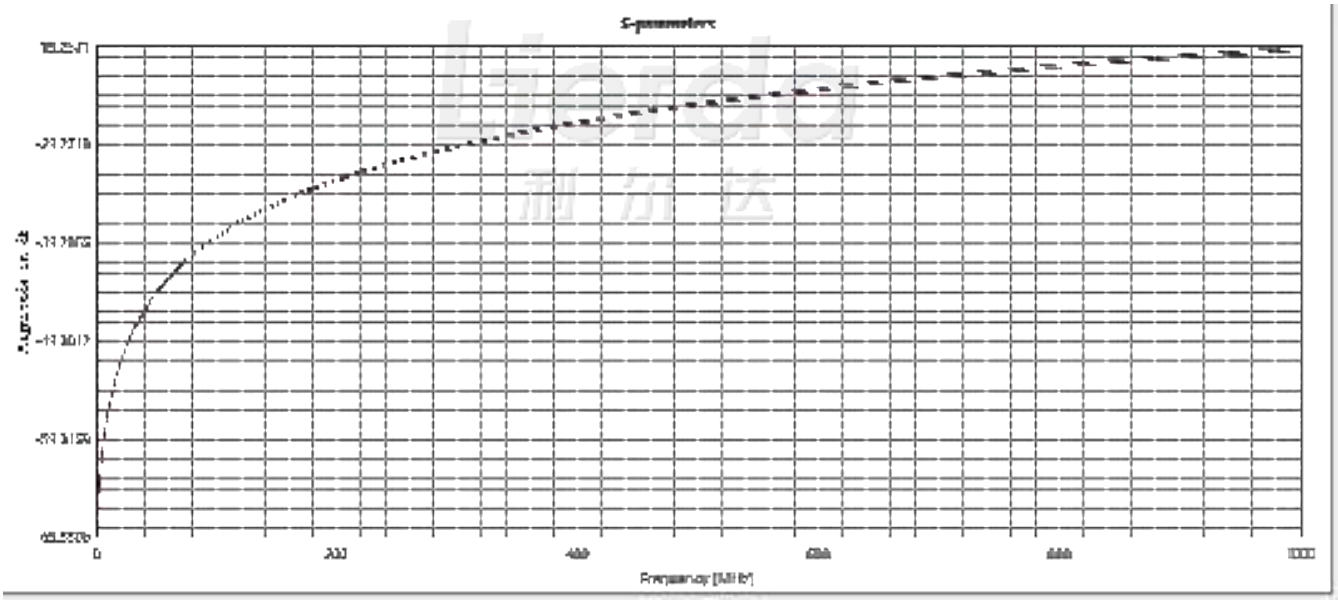


Figure 4.3 S11, S22, S33, S44 parameter analysis of USB differential line of UB61 module

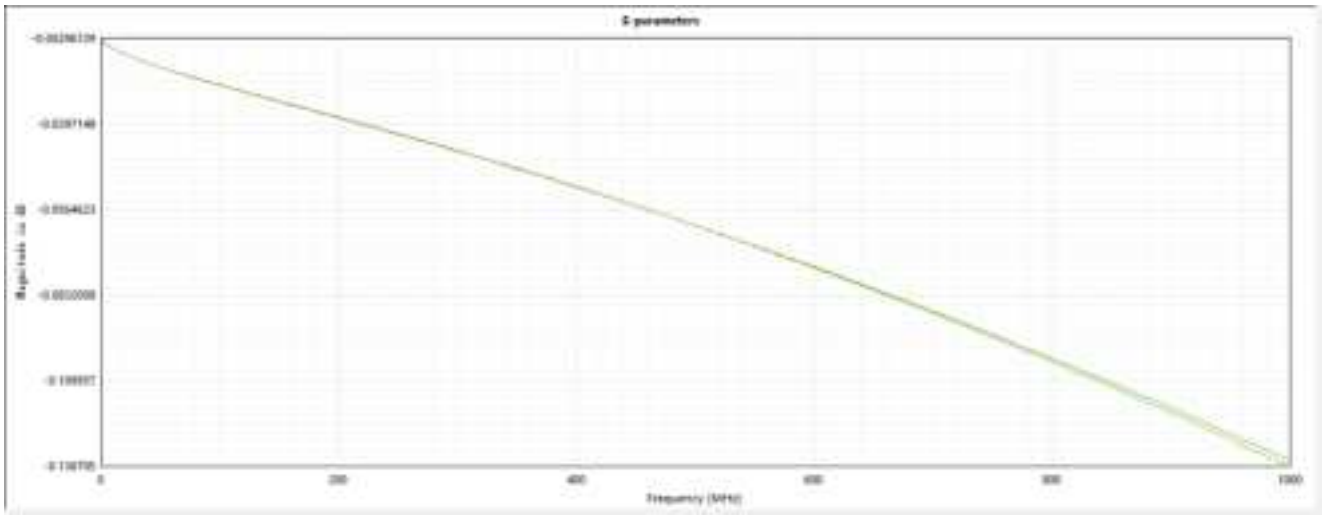


Figure 4.4 Analysis of S12 and S34 parameters of USB differential line of UB61 module

For USB differential signals, when connecting with external USB connectors, TVS diodes need to be added to improve ESD protection.

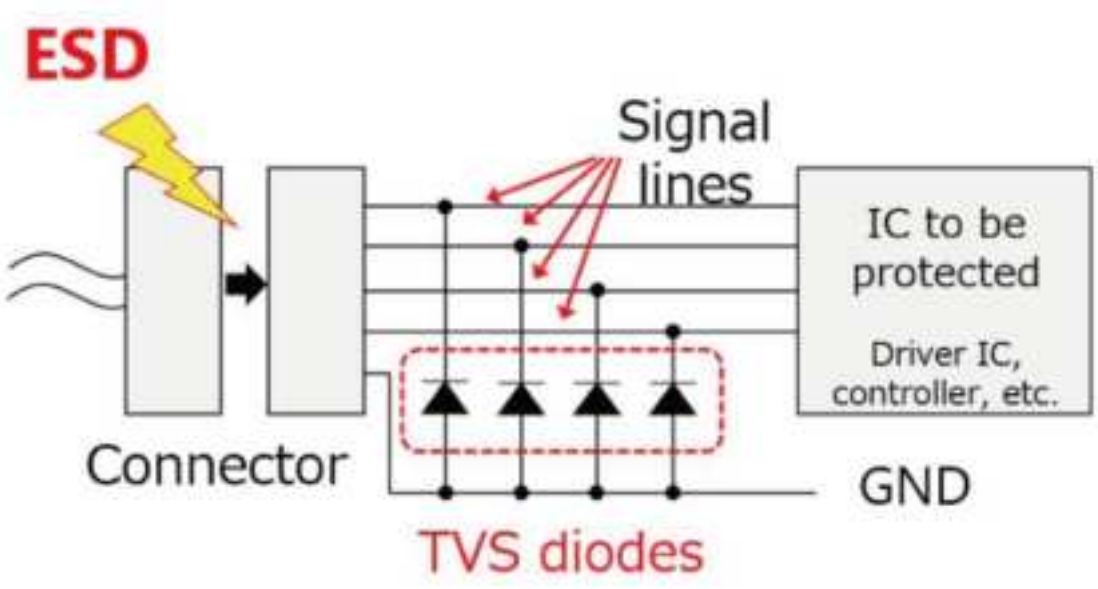



Figure 4.5 TVS diode protection IC

When the circuit is in normal working condition, the TVS diode is in the off state, and the simplified equivalent circuit of the TVS diode is shown below. When the TVS diode is off, the TVS diode acts like a capacitor through the junction capacitance. This capacitance is called the total capacitance CT. Since this capacitance is between the signal line (data path) and GND, the signal integrity of high-speed signals will be degraded. To maintain signal integrity, the TVS diode must be chosen with a sufficiently small total capacitance, CT.

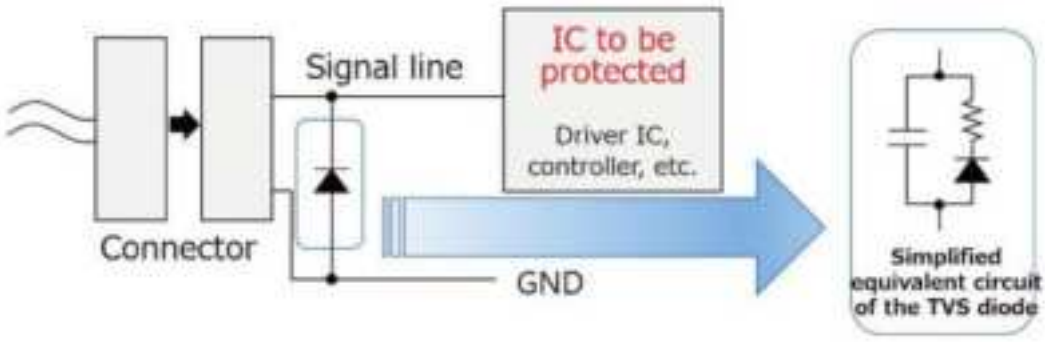



Figure 4.6 TVS Diode Equivalent Circuit

When using TVS diodes to protect high-speed signals, refer to Figure 4.7 TVS diode junction capacitance selection reference. It is recommended to select TVS protection diodes with a junction capacitance of less than 0.6pF for USB2.0 signal ports.

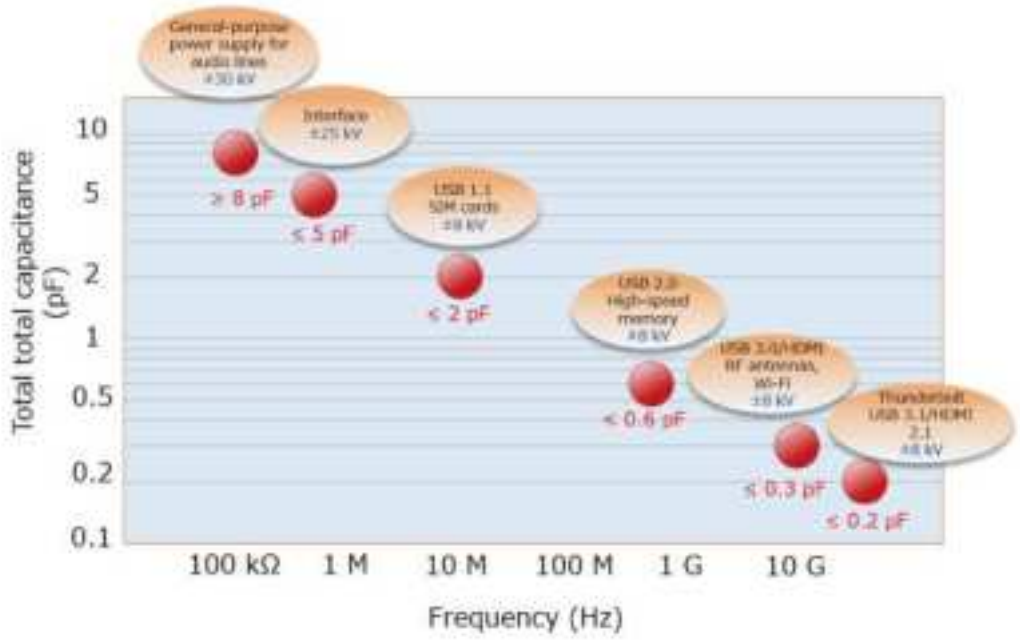



Figure 4.7 TVS diode junction capacitance selection reference

# 5 RF Characteristics

## 5.1 Wi-Fi RF Characteristics

| Feature | Description | |
|---|---|---|
| WLAN Standard | IEEE 802.11b/g/n/ax(@2.4GHz), Wi-Fi compliant | |
| Frequency Range | 2.400 GHz ~ 2.4835 GHz (2.4 GHz ISM Band) | |
| Number of Channels | 2.4GHz：Ch1 ~ Ch14 | |
| Modulation | 802.11b | DQPSK, DBPSK, CCK |
| | 802.11 g/n : OFDM | 64-QAM,16-QAM, QPSK, BPSK |
| | 802.11 ax : OFDMA | 1024-QAM,256-QAM, 64-QAM, 16-QAM, QPSK, BPSK |
| Output Power | 802.11b / 1Mbps | 19 dBm ± 2 dB @ EVM ≤ -10.5dB |
| | 802.11b /11Mbps | 19 dBm ± 2 dB @ EVM ≤ -15.5dB |
| | 802.11g / 6Mbps | 14 dBm ± 2 dB @ EVM ≤ -5dB |
| | 802.11g /54Mbps | 14 dBm ± 2 dB @ EVM ≤ -25dB |
| | 802.11n /MCS0 (20/40M) | 14 dBm ± 2 dB @ EVM ≤ -5dB |
| | 802.11n /MCS7 (20/40M) | 14 dBm ± 2 dB @ EVM ≤ -27dB |
| | 802.11ax /HE0 (20/40M) | 14 dBm ± 2 dB @ EVM ≤ -5dB |
| | 802.11ax /HE9 (20/40M) | 14 dBm ± 2 dB @ EVM ≤ -32dB |
| | 802.11ax /HE11 (20/40M) | 13 dBm ± 3 dB @ EVM ≤ -35dB |
| Freq. Tolerance | ±20 ppm | |
| Receive Sensitivity (11b,20MHz) @8% PER | 1Mbps | PER @ -96.5 dBm, typical |
| | 11Mbps | PER @ -89.5 dBm, typical |
| Receive Sensitivity (11g,20MHz) | 6Mbps | PER @ -92.5 dBm, typical |
| | 54Mbps | PER @ -76.5 dBm, typical |

| | | |
|---|---|---|
| @10% PER | | |
| Receive Sensitivity (11n,20MHz) @10% PER | MCS=0 | PER @ -93 dBm, typical |
| | MCS=7 | PER @ -74.5 dBm, typical |
| Receive Sensitivity (11n,40MHz) @10% PER | MCS=0 | PER @ -90.5 dBm, typical |
| | MCS=7 | PER @ -71.5 dBm, typical |
| Receive Sensitivity (11ax,20MHz) @10% PER | MCS=0 | PER @ -92.5 dBm, typical |
| | MCS=7 | PER @ -74 dBm, typical |
| | MCS=8 | PER @ -70 dBm, typical |
| | MCS=9 | PER @ -68 dBm, typical |
| Receive Sensitivity (11ax,40MHz) @10% PER | MCS=0 | PER @ -89.5 dBm, typical |
| | MCS=7 | PER @ -70.5 dBm, typical |
| | MCS=8 | PER @ -67 dBm, typical |
| | MCS=9 | PER @ -64.5 dBm, typical |

## 5.2 BT RF Characteristics

### 5.2.1 BR+EDR Mode

| Feature | Description | |
|---|---|---|
| Bluetooth Standard | BR+EDR | |
| Frequency Range | 2.402 GHz ~ 2.480 GHz | |
| Channels | BR/EDR：Ch0 ~ Ch78 | |
| Modulation | BR (1M) | GFSK |
| | EDR (2M) | π/4-DQPSK |
| | EDR (3M) | 8DPSK |
| Output Power | BR (1M) | 5dBm(default ) |
| | EDR (2M) | 0dBm(default ) |
| | EDR (3M) | 0dBm(default ) |
| Sensitivity @BER=0.1% for GFSK(1Mbps) | -96dBm | |
| Sensitivity @BER=0.01% for π/4-DQPSK(2Mbps) | -96dBm | |
| Sensitivity @ BER=0.01% for 8DPSK(3Mbps) | -90dBm | |
| Maximum Input Level | GFSK(1Mbps) | -10dBm |
| | π/4-DQPSK(2Mbps) | -10dBm |
| | 8DPSK(3Mbps) | -15dBm |

### 5.2.2 LE Mode

| Feature | Description |
|---|---|
| Bluetooth Standard | BT5.2 |
| Frequency Range | 2.402 GHz ~ 2.480 GHz |
| Channels | LE：Ch0 ~ Ch39 |
| Modulation | GFSK |
| Output Power | 5dBm(default ) |
| Sensitivity @ PER=30.8% for LE(1Mbps) | -99dBm |
| Sensitivity @ PER=30.8% for LE(2Mbps) | -96dBm |
| Sensitivity, @ PER=30.8% for LE Coded (S=2) | -103dBm |
| Sensitivity, @ PER=30.8% for LE Coded (S=8) | -108dBm |
| Maximum Input Level | -10dBm |

## 5.3 Reference Design

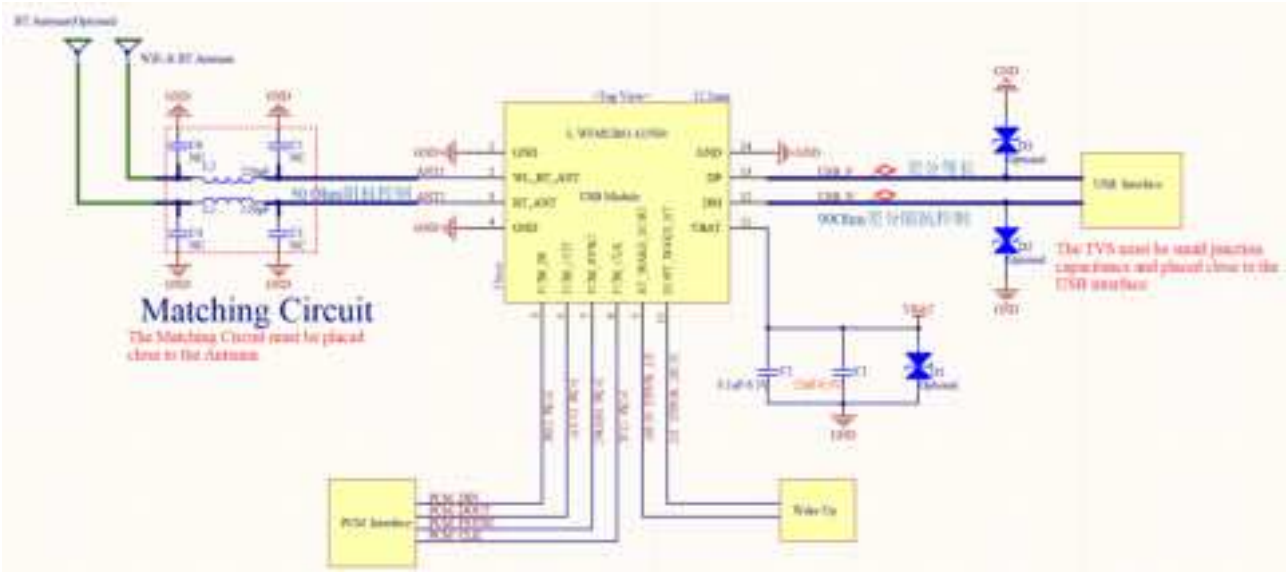



Figure 5.1 UB61 module hardware reference design

## 5.4 Antenna Design Requirements

The UB61 module has two RF interfaces, WL_BT_ANT and BT_ANT.

The WL_BT_ANT pin is a Wi-Fi&BT Combo interface. This interface can be used to work under the condition of time division multiplexing (driver support), and transmit Wi-Fi and BT signals separately, saving materials and space.

The BT function can also be used independently through the BT_ANT interface, and WL_BT_ANT is a separate WiFi port at this time.

When using dual antennas, issues such as antenna isolation and time division need to be considered to avoid co-channel interference.

Generally, the methods to improve the antenna isolation are as follows:

1) Increase the space distance between the two antennas;
2) Stagger the radiation direction of the antenna;
3) Increase the isolation wall;
4) The polarization directions of two independent antennas are vertical (not applicable);

5) Add decoupling network.

It is recommended that users use methods 1 and 2 to increase isolation.

When using an external antenna, especially a monopole antenna, it may be reflected due to the mismatch between the antenna impedance and the transmission line, which will affect the use effect. It is necessary to reserve a matching circuit on the bottom plate to successfully match the antenna system with the transmission line, reduce the loss caused by reflection, and improve the overall efficiency of the antenna system. The matching circuit should be placed as close to the antenna as possible.

It is recommended to use the pi-type matching circuit as shown in Figure 5.2 RF interface and matching circuit design reference. This matching circuit can adjust any impedance to 50 Ohm, where L1 & L2 use 220pF capacitors or 0R resistors by default, and C3, C4, C5 & C6 are used as pre-matching Finally, according to the actual debugging results, determine the final values of L1, L2, C3, C4, C5 and C6.

The dark blue thick line should ensure the impedance control of 50Ω, and the wiring should be as short as possible, without punching holes or sharp-angled lines. Drill more GND vias around the RF traces.

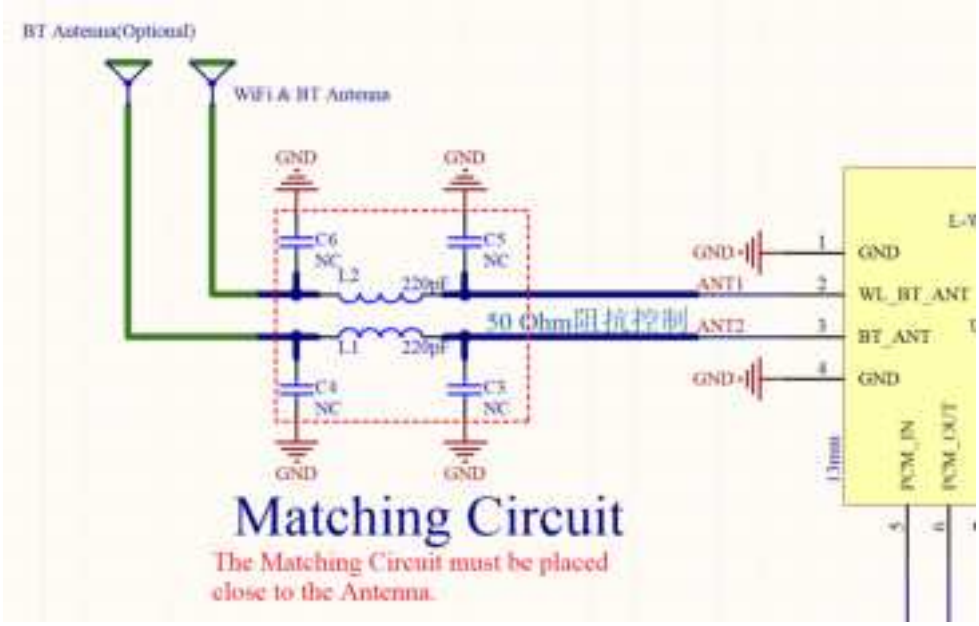



Figure 5.2 RF interface and matching circuit design reference

When in use, as shown in Figure 5.3 The impedance line of the base plate, the wiring connecting the bottom board to the ANT 1 and ANT 2 ports should control the characteristic impedance of 50Ω.

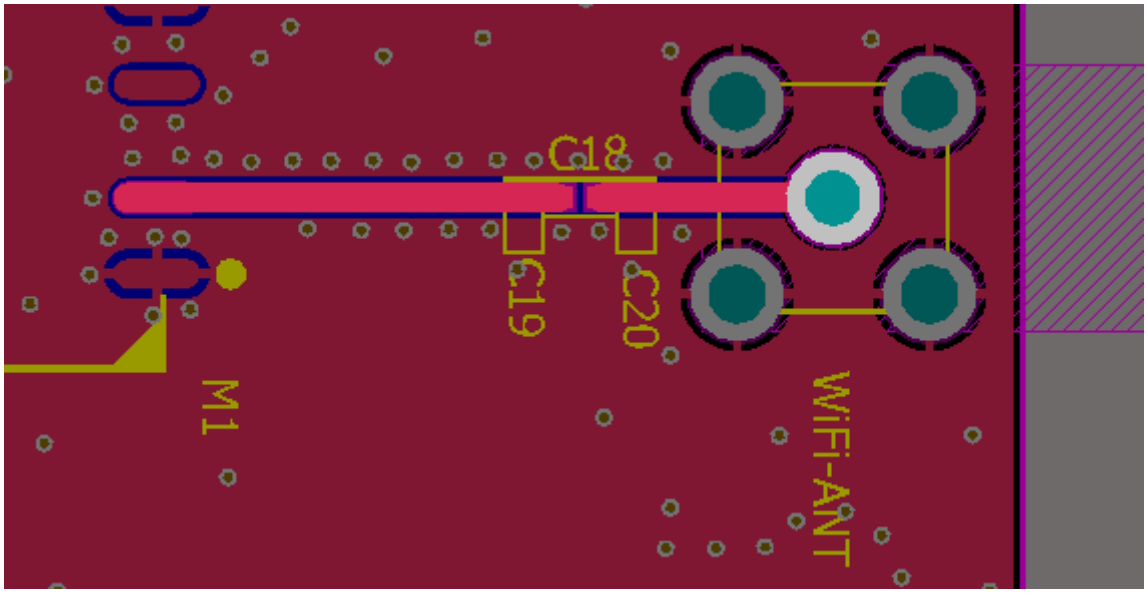



Figure 5.3 The impedance line of the base plate

The relationship between plate thickness, line width and line spacing can be referred to:

Recommended values for FR4 double-sided panels (H=board thickness, W=line width, D=distance between traces and copper clad)

- H=1.0mm，W=0.8mm，D=0.2mm
- H=1.0mm，W=1.0mm，D=0.254mm(Recommendation)
- H=1.2mm，W=1.0mm，D=0.2mm(Recommendation)
- H=1.6mm，W=1.0mm，D=0.2mm(Recommendation)

(You can consult Lierda Technology for more design support)

For the pi-shaped matching circuit, it is recommended to place it as shown in Figure 5.4 Matching circuit design to avoid introducing additional parasitic parameters that affect the difficulty of debugging.

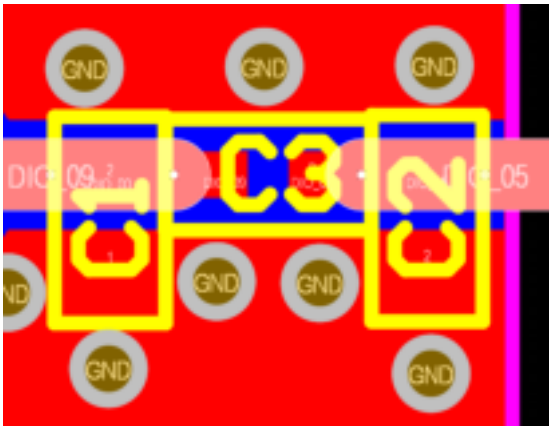


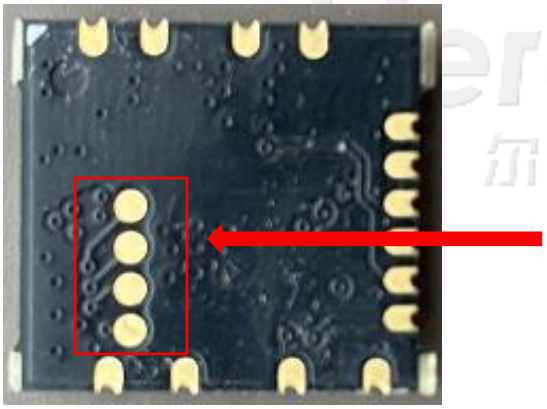

Figure 5.4 Matching circuit design

## 5.5 Backplane Layout Considerations

There is no high-speed signal or sensitive signal routing on the BOTTOM layer of the UB61 module, but it is recommended to design the routing on the TOP layer of the bottom board to avoid the module to avoid unexpected factors.

There are not too many hollowing-out processing requirements in the design of the bottom board. In addition to the general requirements to avoid interference sources mentioned above, the bottom board can almost be covered with copper on the entire board. However, the test point pads on the BOTTOM layer of the module are open to expose copper. It needs to be avoided. The corresponding position of the bottom plate should not place via holes or exposed copper, and it should be covered with white oil to prevent short circuit.

Description of the test points of the Bottom layer of the UB61 module：



**In the 5.6*1.5mm area of the upper left corner of the module BOTTOM layer, there are 4 test point pads with windows and exposed copper. It is best not to go to the position mapped to the bottom plate area.**

Figure 5.5 The pad position of the test point at the bottom of the UB61 module

# 6 Electrical Performance and Reliability

## 6.1 Power Rating

| | Description | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | Power Supply | 3.0 | 3.3 | 3.6 | V |

## 6.2 Power Consumption

| | Description | Max Current @TX (mA) | Max Current @RX (mA) |
|---|---|---|---|
| Wi-Fi | CW @13dBm | 215 | / |
| | 802.11b,11Mbps @19dBm | 305 | 44 |
| | 802.11g,54Mbps @14dBm | 194 | 44 |
| | 802.11n,HT20,MCS0 @14dBm | 216 | 44 |
| | 802.11n,HT20,MCS7 @14dBm | 193 | 44 |
| | 802.11n,HT40,MCS0 @14dBm | 212 | 44 |
| | 802.11n,HT40,MCS7 @14dBm | 177 | 44 |
| | 802.11ax,HE20,MCS0 @14dBm | 216 | 44 |
| | 802.11ax,HE20,MCS11 @14dBm | 182 | 44 |
| | 802.11ax,HE40,MCS0 @14dBm | 211 | 44 |
| | 802.11ax,HE40,MCS11 @14dBm | 171 | 44 |
| BT | CW @default power(5.1dBm) | 43 | / |
| | CW @max power(7.4dBm) | 49 | / |
| | CW @(0 dBm) | 37 | / |
| | BR @DH5 default power | 39 | 33 |
| | EDR @2-DH5 default power | 35 | 33 |
| | EDR @3-DH5 default power | 35 | 33 |
| | BLE @1M default power | 40 | 34 |
| | BLE @2M default power | 34 | 35 |
| | BLE @S=8 default power | 43 | 36 |
| | BLE @S=2 default power | 42 | 36 |

## 6.3 Digital Logic Level Characteristics

| | Description | MIn | Typ | Max | Unit |
|---|---|---|---|---|---|
| $V_{IL}$ | CMOS Low Level Input Voltage | 0 | / | 0.3*VDD | V |
| $V_{IH}$ | CMOS High Level Input Voltage | 0.7*VDD | / | VDD | V |
| $V_{TH}$ | CMOS Threshold Voltage | / | 0.5*VDD | / | V |

## 6.4 ESD Performance

| | Description | MIn | Typ | Max | Unit |
|---|---|---|---|---|---|
| $V_{ESD}$ | VDD&ANT PIN ESD performance | / | 2 | / | kV |

## 6.5 Temperature

| | Description | MIn | Typ | Max | Unit |
|---|---|---|---|---|---|
| $T_A$ | Operating temperature | -20 | / | +80 | ℃ |
| $T_{Storage}$ | Storage temperature | -40 | / | +85 | ℃ |

# 7 Dimensions

## 7.1 Physical Dimensions


Figure 7.1 Dimensions of the module

# 8 Production and Packaging Information

## 8.1 Production Welding

### 8.1.1 Production Instructions

It is recommended to use SMT machine to mount the stamp mouth packaging module, and the mounting should be completed within 24 hours after unpacking, otherwise, it should be vacuum-packed again to avoid moisture and poor mounting.

If the package contains a humidity indicator card, it is recommended to judge whether the module needs to be baked according to the humidity card. The conditions for baking are as follows:

Baking temperature: 125℃±5℃;

The alarm temperature is set to 130°C;

After cooling <36°C under natural conditions, SMT patching can be carried out;

If the unpacking time exceeds 3 months, you need to pay special attention to whether the product is damp. Because of the PCB immersion gold process, more than 3 months may cause oxidation of the pads, which may cause problems such as virtual soldering and missing soldering during placement.

In order to ensure the qualified rate of reflow soldering, it is recommended to select 10% of the products for visual inspection and AOI inspection for the first placement, so as to ensure the rationality of furnace temperature control, device adsorption method and placement method;

Operators at each station must wear electrostatic gloves during the whole production process;

### 8.1.2 Module location requirements on the backplane

It is recommended that the thickness of the green oil at the position of the module on the bottom plate be less than 0.02mm to avoid excessive thickness, and the raised module cannot effectively contact the solder paste and affect the soldering quality. In addition, it is necessary to consider that other devices cannot be placed within 2mm around the interface board module to ensure the maintenance of the module.

### 8.1.3 Stencil Opening Design

In principle, the thickness of the stencil on the bottom plate is selected based on the comprehensive consideration of the package type of the device on the board. The following requirements need to be focused on:

The pad position of the module can be partially thickened to 0.15~0.20mm to avoid empty soldering.

### 8.1.4 Production Notes

- During the production process, each operator must wear electrostatic gloves;
- Do not exceed the specified baking time when baking;
- It is strictly forbidden to add explosive, flammable and corrosive substances during baking;
- When baking, the modules should be placed in a high-temperature tray to keep the air circulation between the modules;
- When baking, the oven door must be closed to ensure that the oven is closed to prevent temperature leakage;
- Try not to open the door when the oven is running. If it must be opened, try to shorten the time for opening the door;

- After baking, wait for the module to cool naturally below 36° C before taking it out with electrostatic gloves to avoid burns;
- During operation, strictly prevent the bottom surface of the module from getting water or dirt;

### 8.1.5 Recommended Reflow Profile

Note: This work guide is only suitable for lead-free work and is for reference only.

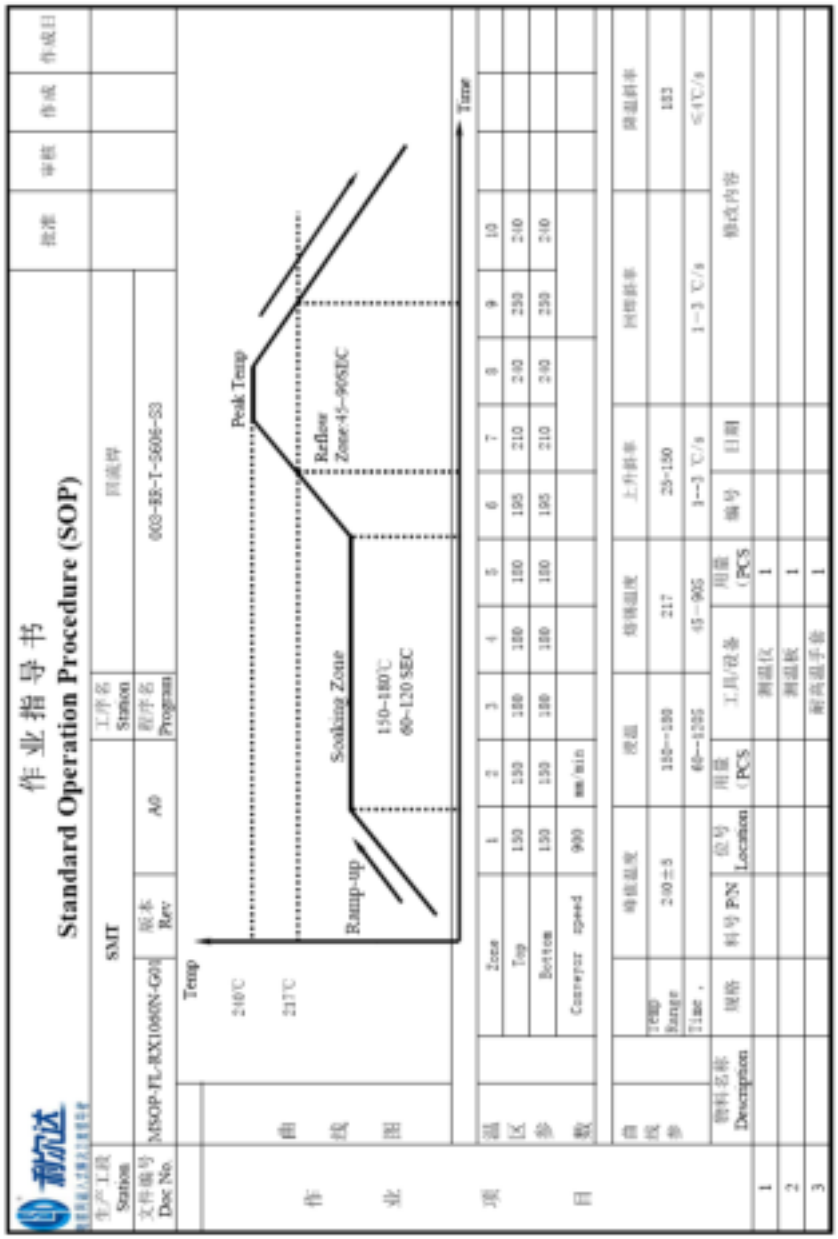



Figure 8.1 Reflow Soldering Operation Instructions

## 8.2 Package Information

### 8.2.1 Packaging Method

| Model Name | Method | Packing Case (pcs) | MPQ(pcs) | Reels per Case |
|---|---|---|---|---|
| L-WFMUB61-G5NI4 | Tape and Reel | 6500 | 1300 | 5 |

### 8.2.2 Carrier Size Detail

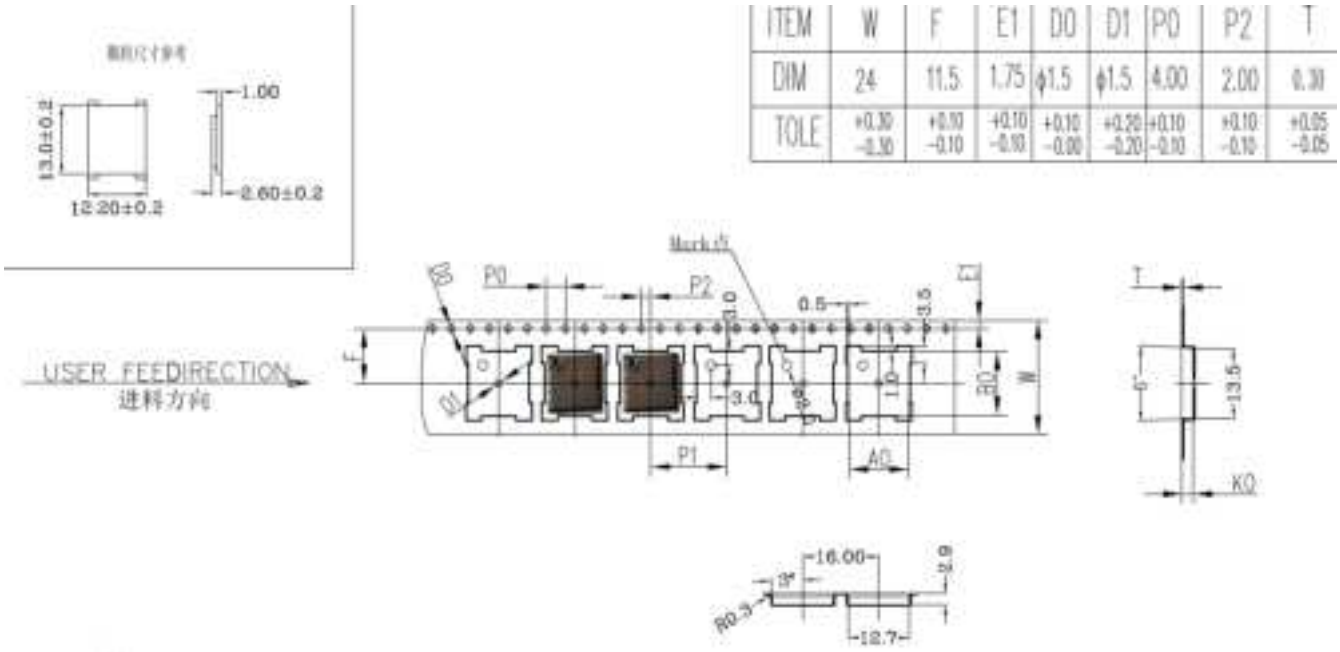



Figure 8.2 Carrier size and product orientation

Federal Communication Commission (FCC) Radiation Exposure Statement

When using the product, maintain a distance of 20cm from the body to ensure compliance with RF exposure requirements.

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.

NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications or changes to this equipment. Such modifications or changes could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

ORIGINAL EQUIPMENT MANUFACTURER (OEM) NOTES

The OEM must certify the final end product to comply with unintentional radiators (FCC Sections 15.107 and 15.109) before declaring compliance of the final product to Part 15 of the FCC rules and regulations. Integration into devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change.

The OEM must comply with the FCC labeling requirements. If the module's label is not visible when installed, then an additional permanent label must be applied on the outside of the finished product which states: "Contains transmitter module FCC ID: 2AOFDL-WFMUB61. Additionally, the following statement should be included on the label and in

the final product's user manual: "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 interferences, and

(2) this device must accept any interference received, including interference that may cause undesired operation."

The module is allowed to be installed in mobile and portable applications A module or modules can only be used without additional authorizations if they have been tested and granted under the same intended end - use operational conditions, including simultaneous transmission operations. When they have not been tested and granted in this manner, additional testing and/or FCC application filing may be required. The most straightforward approach to address additional testing conditions is to have the grantee responsible for the certification of at least one of the modules submit a permissive change application. When having a module grantee file a permissive change is not practical or feasible, the following

guidance provides some additional options for host manufacturers. Integrations using modules where additional testing and/or FCCapplication filing(s) may be required are: (A) a module used in devices requiring additional RF exposure compliance information (e.g., MPE evaluation or SAR testing); (B) limited and/or split modules not meeting all of the module requirements; and (C) simultaneous transmissions for independent collocated transmitters not previously granted together.

This Module is full modular approval, it is limited to OEM installation ONLY. Integration into devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change. (OEM) Integrator has to assure compliance of the entire end product include the integrated Module. Additional measurements (15B) and/or equipment authorizations(e.g. Verification) may need to be addressed depending on co-location or simultaneous transmission issues if applicable.(OEM) Integrator is reminded to assure that these installation instructions will not be made available to the end user.