INSTALLATION AND OPERATION

USER MANUAL

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UM960

GPS/BDS/GLONASS/Galileo/QZSS
All-constellation Multi-frequency
High Precision RTK Positioning Module

Revision History

Version	Revision History	Date
R1.0	First release	Sep., 2022
R1.1	Added section 3.1 Recommended Minimal Design Optimized section 3.2 Antenna Feed Design Optimized section 3.3 Power-on and Power-off Added section 3.5 Recommended PCB Package Design	Jun., 2023
R1.2	Added B2b and E6 to the supported frequencies Updated the logo on the module and label illustrations Updated section 3.3 Power-on and Power-off Added suggestions on heat dissipation in section 3.4	Aug., 2024

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Foreword

This document describes the information of the hardware, package, specification and the use of Unicore UM960 modules.

Target Readers

This document applies to technicians who possess the expertise on GNSS receivers.

Contents

1 Introduction

UM960 is a new generation of GNSS high precision positioning RTK module from Unicore. It supports all constellations and multiple frequencies, and can simultaneously track GPS L1C/A, L2P, L5 + BDS B1I, B2I, B3I, B1C, B2a, B2b* + GLONASS G1, G2 + Galileo E1, E5b, E5a, E6* + QZSS L1, L2, L5 + SBAS L1C/A. The module is mainly used in UAVs, lawn mower, handheld device, high precision GIS, precise agriculture, and intelligent drive.

UM960 is based on NebulasIV, a GNSS SoC which integrates RF-baseband and high precision algorithm. Besides, the SoC integrates a dual-core CPU, a high speed floating point processor and an RTK co-processor with 22 nm low power design, and it supports 1408 super channels and realizes 20 Hz RTK positioning output. All these above enable stronger signal processing.

UM960 features a compact size of 16.0 mm × 12.2 mm. It adopts SMT pads, supports standard pick-and-place and fully automated integration of reflow soldering.

Furthermore, UM960 supports interfaces such as UART, I²C^Δ, which meets the customers' needs in different applications.

Figure 1-1 UM960 Module

* Supported by specific firmware.

Δ Reserved interface, not supported currently.

1.1 Key Features

- High precision, compact size and low power consumption
- Based on the new generation GNSS SoC -NebulasIV, with RF-baseband and high precision algorithm integrated
- 16.0 mm × 12.2 mm × 2.6 mm, surface-mount device
- Supports all-constellation multi-frequency on-chip RTK positioning solution
- Supports GPS L1C/A, L2P, L5 + BDS B1I, B2I, B3I, B1C, B2a, B2b* + GLONASS G1, G2 + Galileo E1, E5b, E5a, E6* + QZSS L1, L2, L5 + SBAS L1C/A
- All constellations and multiple frequencies RTK engine, and advanced RTK processing technology
- Independent tracking of different frequencies, and 60 dB narrowband anti-jamming
- Advanced function of jamming detection

1.2 Key Specifications

Table 1-1 Technical Specifications

Basic Information		
Channels	1408 channels, based on NebulasIV	
Constellations	GPS/BDS/GLONASS/Galileo/QZSS	
Frequency	GPS: L1C/A, L2P, L5 BDS: B1I, B2I, B3I, B1C, B2a, B2b* GLONASS: G1, G2 Galileo: E1, E5b, E5a, E6* QZSS: L1, L2, L5 SBAS: L1C/A	
Power		
Voltage	+3.0 V~ +3.6 V DC	
Power Consumption	450mW（Typical）	
Performance		
Positioning Accuracy	Single Point Positioning (RMS)	Horizontal: 1.5 m
		Vertical: 2.5 m
	DGPS (RMS)	Horizontal: 0.4 m
		Vertical: 0.8 m
	RTK (RMS)	Horizontal: 0.8 cm + 1 ppm
		Vertical: 1.5 cm + 1 ppm

* Supported by specific firmware.

Observation Accuracy（RMS）	BDS	GPS	GLONASS	Galileo
B1I/B1C/L1C/A/G1/E1 Pseudorange	10 cm	10 cm	10 cm	10 cm
B1I/B1C/L1C/A/G1/E1 CarrierPhase	1 mm	1 mm	1 mm	1 mm
B3I/L2P/G2/E6 Pseudorange	10 cm	10 cm	10 cm	10 cm
B3I/L2P/G2/E6 Carrier Phase	1 mm	1 mm	1 mm	1 mm
B2I/B2a/B2b/L5/E5a/E5b Pseudorange	10 cm	10 cm	10 cm	10 cm
B2I/B2a/B2b/L5/E5a/E5b Carrier Phase	1 mm	1 mm	1 mm	1 mm
Time Pulse Accuracy (RMS)	20 ns			
Velocity Accuracy (RMS)	0.03 m/s			
Time to First Fix (TTFF)	Cold Start < 30 s			
Initialization Time	< 5 s (Typical)			
Initialization Reliability	> 99.9%			
Data Update Rate	20 Hz Positioning			
Differential Data	RTCM 2.3, RTCM3.x, CMR			
Data Format	NMEA-0183; Unicore			
Physical Specifications				
Package	24 pin LGA			
Dimensions	16.0 mm × 12.2 mm × 2.6 mm			
Environmental Specifications				
Operating Temperature	-40 °C ~ +85 °C			
Storage Temperature	-55 °C ~ +95 °C			
Humidity	95% No condensation			
Vibration	GJB150.16A-2009; MIL-STD-810F			
Shock	GJB150.18A-2009; MIL-STD-810F			
Functional Ports				
UART x 3				
I^2C* x 1				

* Reserved interface, not supported currently.

1.3 Block Diagram

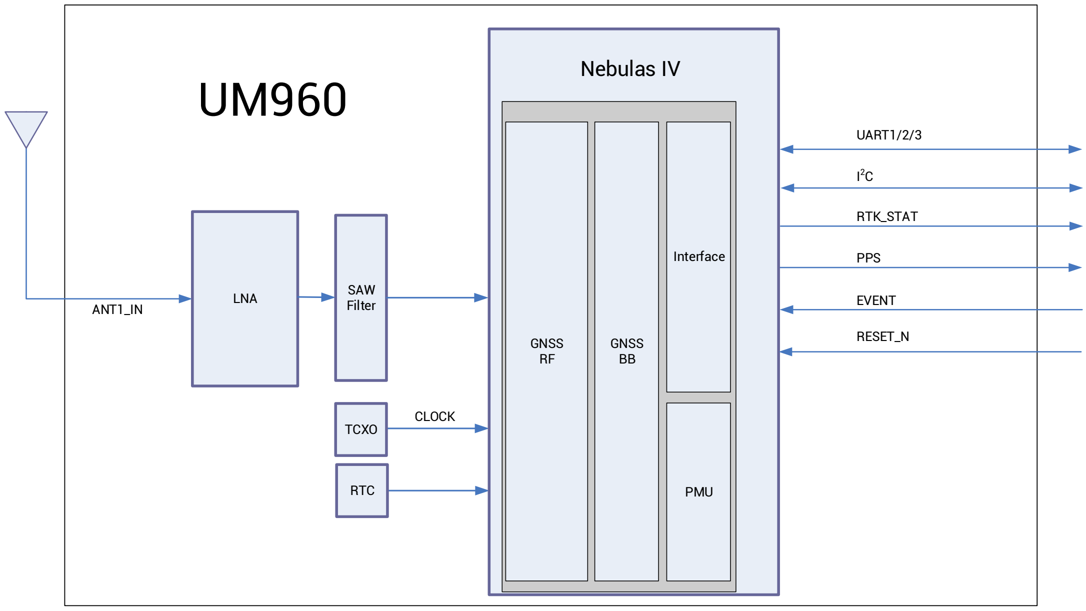

Figure 1-2 UM960 Block Diagram

- RF Part

The receiver gets filtered and enhanced GNSS signal from the antenna via a coaxial cable. The RF part converts the RF input signals into the IF signal, and converts IF analog signals into digital signals required for NebulasIV chip.

- NebulasIV SoC

NebulasIV is Unicore's new generation high precision GNSS SoC with 22 nm low power design, supporting all constellations, multiple frequencies and 1408 super channels. It integrates a dual-core CPU, a high speed floating point processor and an RTK co-processor, which can fulfill the high precision baseband processing and RTK positioning independently.

- External Interfaces

The external interfaces of UM960 include UART, I²C*, PPS, EVENT, RESET_N, etc.

* Reserved interface, not supported currently.

2 Hardware

2.1 Pin Definition

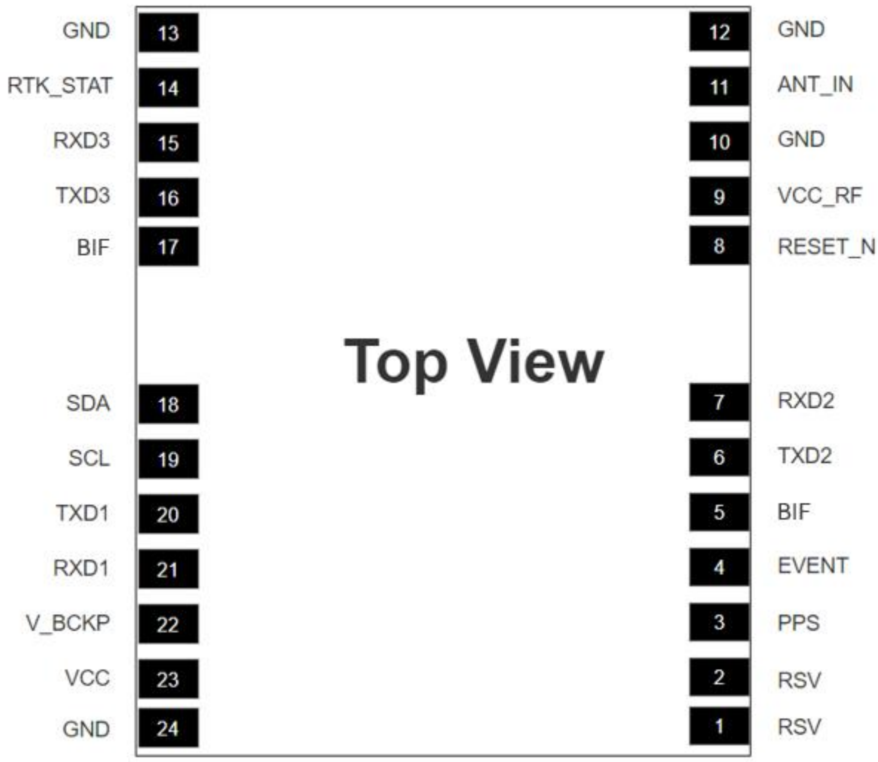

Figure 2-1 UM960 Pin Definition

Table 2-1 Pin Definition

No.	Pin	I/O	Description
1	RSV	—	Reserved, must be floating; cannot connect ground or power supply or peripheral I/O
2	RSV	—	Reserved, must be floating; cannot connect ground or power supply or peripheral I/O
3	PPS	O	Pulse per second, with adjustable pulse width and polarity
4	EVENT	I	Event Mark, with adjustable frequency and polarity
5	RSV	—	Built-in function; recommended to add a through-hole testing point and a 10 kΩ pull-up resistor; cannot connect ground or power supply or peripheral I/O, but can be floating.
6	TXD2	O	UART2 output

No.	Pin	I/O	Description
7	RXD2	I	UART2 input
8	RESET_N	I	System reset; active Low. The active time should be no less than 5 ms.
9	VCC_RF[1]	O	External LNA power supply
10	GND	—	Ground
11	ANT_IN	I	GNSS antenna signal input
12	GND	—	Ground
13	GND	—	Ground
14	RTK_STAT	O	High level: RTK Fix; Low level: RTK No Fix
15	RXD3	I	UART3 input
16	TXD3	O	UART3 output
17	RSV	—	Built-in function; recommended to add a through-hole testing point and a 10 kΩ pull-up resistor; cannot connect ground or power supply or peripheral I/O, but can be floating.
18	SDA	I/O	I^2C data
19	SCL	I/O	I^2C clock
20	TXD1	O	UART1 output
21	RXD1	I	UART1 input
22	V_BCKP	I	When the main power supply VCC is cut off, V_BCKP supplies power to RTC and relevant register. Level requirement: 2.0 V ~ 3.6 V, and the working current is less than 60 μA at 25 °C. If you do not use the hot start function, connect V_BCKP to VCC. Do NOT connect it to ground or leave it floating.
23	VCC	I	Supply voltage
24	GND	—	Ground

[1] Not recommended to take VCC_RF as ANT_BIAS to feed the antenna. See section 3.2 for more details.

2.2 Electrical Specifications

2.2.1 Absolute Maximum Ratings

Table 2-2 Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit
Power Supply (VCC)	VCC	-0.3	3.6	V
Voltage Input	V_{in}	-0.3	3.6	V
GNSS Antenna Signal Input	ANT_IN	-0.3	6	V
RF Input Power of Antenna	ANT_IN input power		+10	dBm
External LNA Power Supply	VCC_RF	-0.3	3.6	V
VCC_RF Output Current	ICC_RF		100	mA
Storage Temperature	T_{stg}	-55	95	°C

2.2.2 Operating Conditions

Table 2-3 Operational Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Power Supply (VCC)	VCC	3.0	3.3	3.6	V	
Maximum Ripple Voltage	V_{rpp}	0		50	mV	
Working Current[2]	I_{opr}		136	218	mA	VCC = 3.3 V
VCC_RF Output Voltage	VCC_RF		VCC-0.1		V	
VCC_RF Output Current	ICC_RF			50	mA	
Operating Temperature	T_{opr}	-40		85	°C	
Power Consumption	P		450		mW	

[2] Since the product has capacitors inside, inrush current occurs during power-on. You should evaluate in the actual environment in order to check the effect of the supply voltage drop caused by inrush current in the system.

2.2.3 IO Threshold

Table 2-4 IO Threshold

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Low Level Input Voltage	V_{in_low}	0		VCC × 0.2	V	
High Level Input Voltage	V_{in_high}	VCC × 0.7		VCC + 0.2	V	
Low Level Output Voltage	V_{out_low}	0		0.45	V	I_{out}= 4 mA
High Level Output Voltage	V_{out_high}	VCC - 0.45		VCC	V	I_{out} =4 mA

2.2.4 Antenna Feature

Table 2-5 Antenna Feature

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Optimum Input Gain	G_{ant}	18	30	36	dB	

2.3 Dimensions

Table 2-6 Dimensions

Symbol	Min.(mm)	Typ. (mm)	Max. (mm)
A	15.80	16.00	16.50
B	12.00	12.20	12.70
C	2.40	2.60	2.80
D	0.90	1.00	1.10
E	0.20	0.30	0.40
F	1.40	1.50	1.60
G	1.00	1.10	1.20
H	0.70	0.80	0.90
J	3.20	3.30	3.40
N	2.90	3.00	3.10
P	1.30	1.40	1.50
R	0.99	1.00	1.10
X	0.72	0.82	0.92
φ	0.99	1.00	1.10

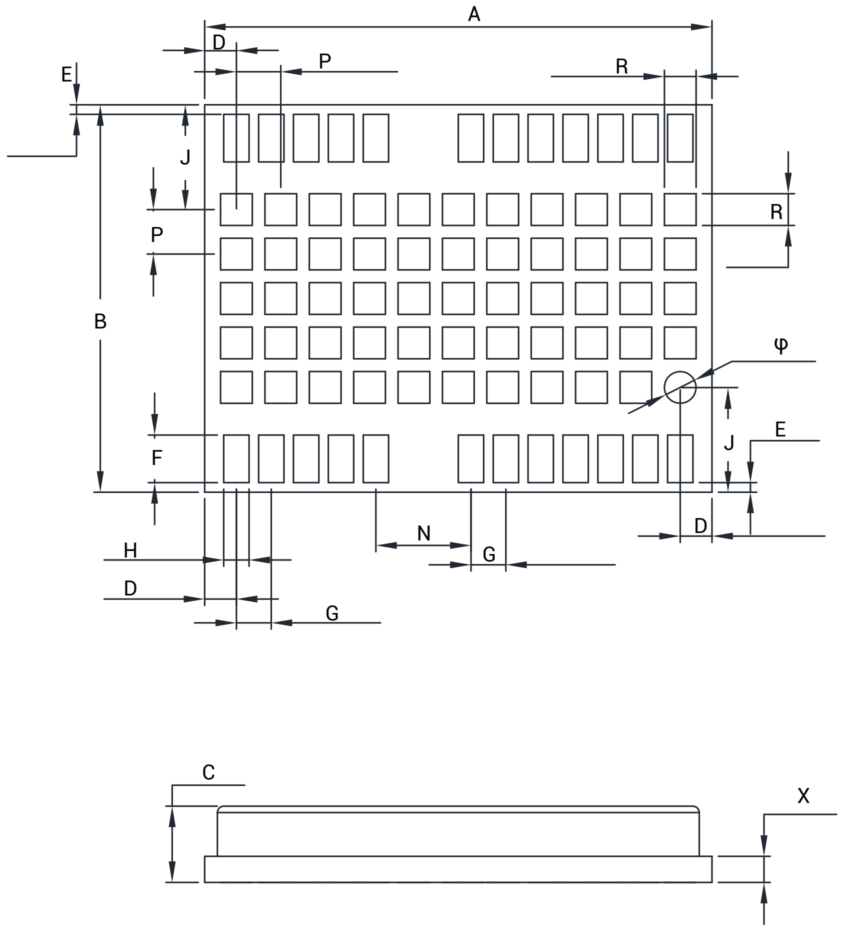

Figure 2-2 UM960 Mechanical Dimensions

3 Hardware Design

3.1 Recommended Minimal Design

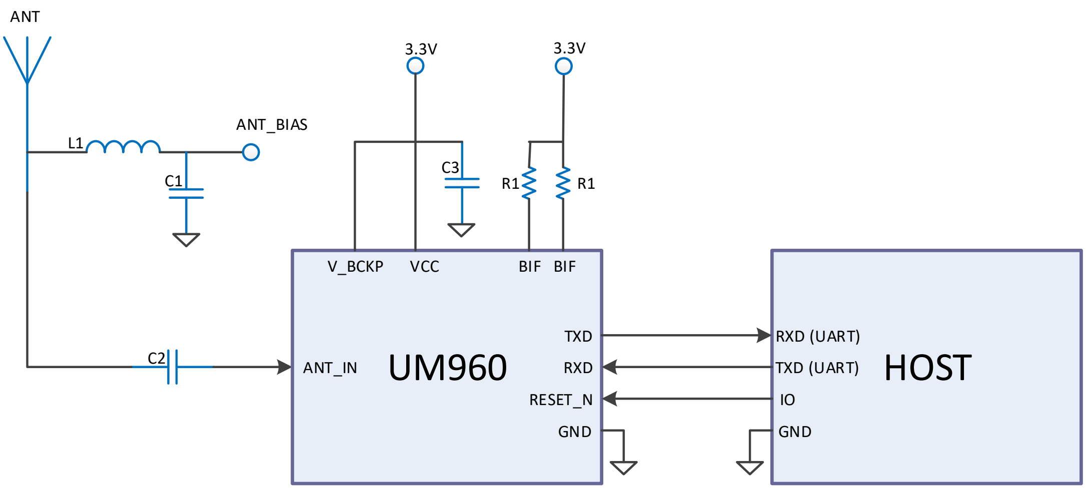

Figure 3-1 UM960 Minimal Design

Remarks:

- L1: 68 nH RF inductor in 0603 package is recommended
- C1: 100 nF + 100 pF capacitors connected in parallel is recommended
- C2: 100 pF capacitor is recommended
- C3: n × 10 μF + 1 × 100 nF capacitors connected in parallel is recommended, and the total inductance should be no less than 30 μF
- R1: 10 kΩ resistor is recommended

3.2 Antenna Feed Design

UM960 just supports feeding the antennal from the outside of the module rather than the inside. It is recommended to use devices with high power and that can withstand high voltage. Gas discharge tube, varistor, TVS tube and other high-power protective devices may also be used in the power supply circuit to further protect the module from lightning strike and surge.

⚠ If the antenna feed supply ANT_BIAS and the module's main supply VCC use the same power rail, the ESD, surge and overvoltage from the antenna will have an effect on VCC, which may cause damage to the module. Therefore, it is recommended to design an independent power rail for the ANT_BIAS to reduce the possibility of module damage.

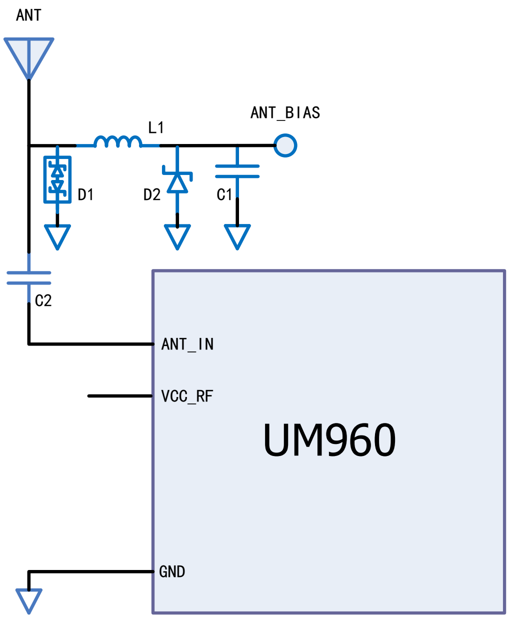

Figure 3-2 UM960 External Antenna Feed Reference Circuit

Remarks:

- L1: feed inductor, 68nH RF inductor in 0603 package is recommended.
- C1: decoupling capacitor, it is recommended to connect two capacitors of 100nF/100pF in parallel.
- C2: DC blocking capacitor, recommended 100pF capacitor.
- Not recommended to take VCC_RF as ANT_BIAS to feed the antenna (VCC_RF is not optimized for the anti-lightning strike and anti-surge due to the compact size of the module).
- D1: ESD diode, choose the ESD protection device that supports high frequency signals (above 2000 MHz).

- D2: TVS diode, choose the TVS diode with appropriate clamping specification according to the requirement of feed voltage and antenna voltage.

3.3 Power-on and Power-off

VCC

- The VCC initial level when power-on should be less than 0.4 V.
- The VCC ramp when power-on should be monotonic, without plateaus.
- The voltages of undershoot and ringing should be within 5% VCC.
- Power-on time interval: The time interval between the power-off (VCC < 0.4 V) to the next power-on must be larger than 500 ms.

V_BCKP

- The V_BCKP initial level when power-on should be less than 0.4 V.
- The V_BCKP ramp when power-on should be monotonic, without plateaus.
- The voltages of undershoot and ringing should be within 5% V_BCKP.
- Power-on time interval: The time interval between the power-off (V_BCKP < 0.4 V) to the next power-on must be larger than 500 ms.

3.4 Grounding and Heat Dissipation

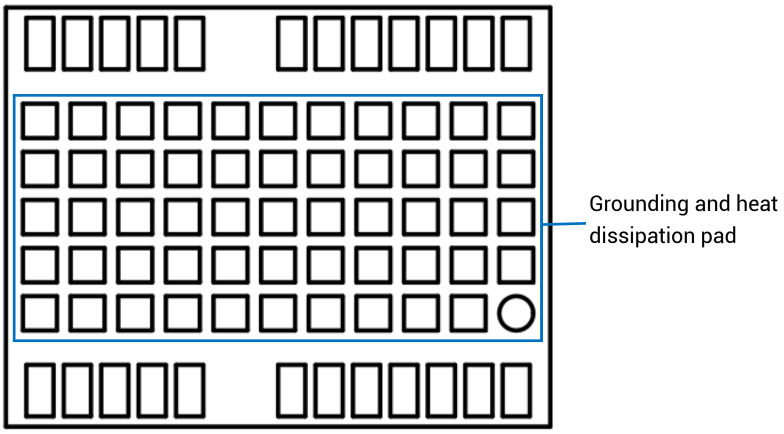

Figure 3-3 Grounding and Heat Dissipation Pad

The 55 pads in the rectangle area in Figure 3-3 are used for grounding and heat dissipation. In the PCB design, they must be connected to a large-sized ground to strengthen the heat dissipation.

UM960 is an industrial-grade product, and when the ambient temperature exceeds the upper limit of 85 °C, there is a small probability that the module's power consumption will be high and affect the reliability of the product. Experiments show that when the temperature is 85 °C and the heat dissipation condition is good, the power consumption of the module is less than 1 W, and it can work normally. But when the ambient temperature increases to 105 °C, with poor heat dissipation of the bottom board in an enclosed space, the power consumption of the module will increase significantly, thus causing reliability problems.

Based on the above experimental results, it is recommended to pay attention to the following points during PCB design:

1) Increase the number of the PCB layers. Six-layer PCB is recommended, at least 4 layers.

2) Use at least 1 oz copper thickness on the top and bottom layers.

3) Lay a large area of grounded copper pour in the 5 cm * 5 cm area under the module on the top and bottom layers, and in the non-routing areas in all layers. Use the internal layers for signal routing and leave space for copper pour. Add dense vias on the top and bottom layers for heat conduction.

4) Expose the copper in the 5 cm * 5 cm area under the module on the top and bottom layers, and use ENIG process to avoid corrosion. When necessary, attach a heat sink in the copper area to further increase the heat dissipation.

5) If conditions permit, use a fan to further enhance the heat dissipation.

It is also recommended to carry out comprehensive thermal design and simulation of the whole machine. During simulation, leave a certain margin for the power consumption of the module and ensure that the temperature of the module is below 85°C.

3.5 Recommended PCB Package Design

See the following figure for the recommended PCB package design of the module UM960.

Unit：mm

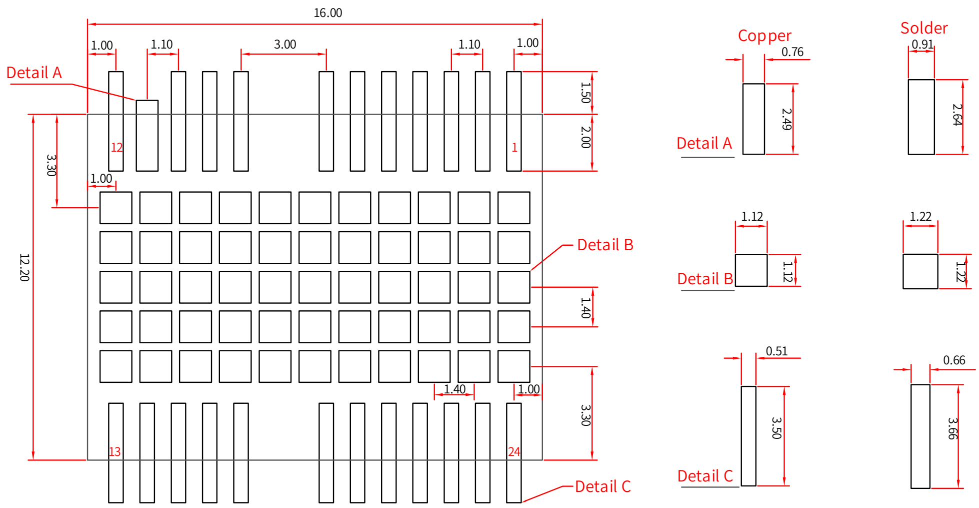

Figure 3-4 Recommended PCB Package Design

Remark:

- For the convenience of testing, the soldering pads of the pins are designed long, exceeding the module border much more. For example:
  - ✓ The pads denoted as detail C are 1.50 mm longer than the module border.
  - ✓ The pad denoted as detail A is 0.49 mm longer than the module border. It is relatively short as it is an RF pin pad, so we hope the trace on the surface is as short as possible to reduce the impact of interference.
- In order to effectively reduce the possibility of solder bridge during the soldering, the pin pads are designed narrower than the pins. However, the pad denoted as detail A has the same width as the pin, as we hope the resistance is as continuous as possible at the RF pin.

4 Production Requirement

Recommended soldering temperature curve is as follows:

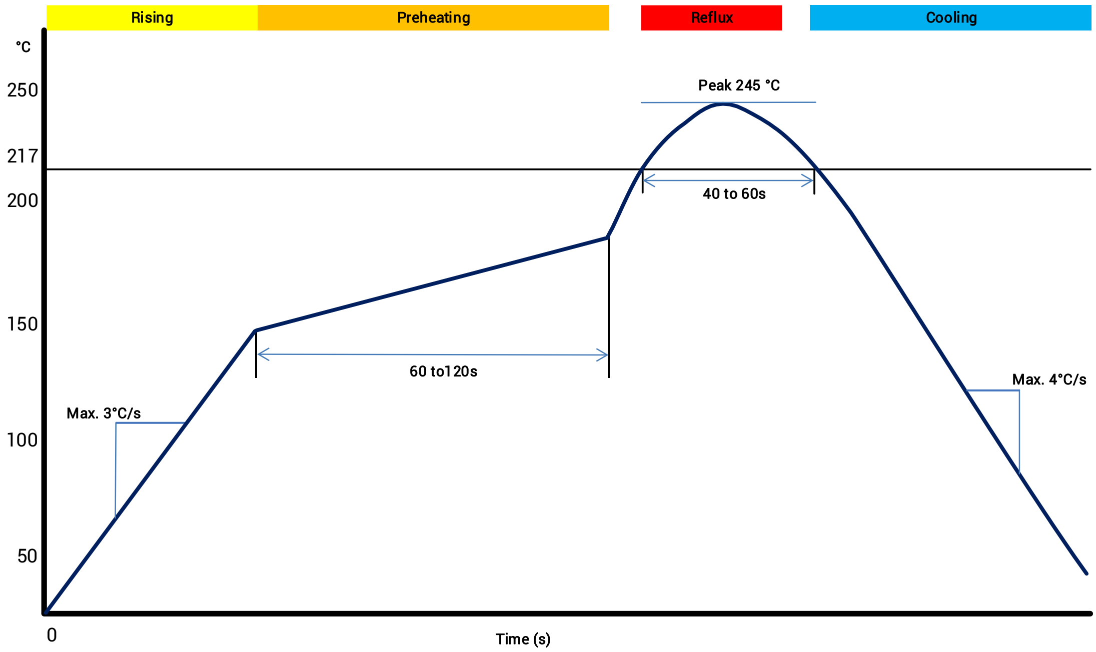

Figure 4-1 Soldering Temperature (Lead-free)

Temperature Rising Stage

- Rising slope: Max. 3 °C/s
- Rising temperature range: 50 °C to 150 °C

Preheating Stage

- Preheating time: 60 s to 120 s
- Preheating temperature range: 150 °C to 180 °C

Reflux Stage

- Over melting temperature (217 °C) time: 40 s to 60 s
- Peak temperature for soldering: no higher than 245 °C

Cooling Stage

- Cooling slope: Max. 4 °C/s

- In order to prevent falling off during soldering of the module, do not solder it on the back of the board during design, that is, better not go through soldering cycle twice.
- The setting of soldering temperature depends on many factors of the factory, such as board type, solder paste type, solder paste thickness, etc. Please also refer to the relevant IPC standards and indicators of solder paste.
- Since the lead soldering temperature is relatively low, if using this method, please give priority to other components on the board.
- The opening of the stencil needs to meet your design requirement and comply with the examine standards. The thickness of the stencil is recommended to be 0.15 mm.

5 Packaging

5.1 Label Description

Figure 5-1 Label Description

5.2 Product Packaging

The UM960 module uses carrier tape and reel (suitable for mainstream surface mount devices), packaged in vacuum-sealed aluminum foil antistatic bags, with a desiccant inside to prevent moisture. When using reflow soldering process to solder modules, please strictly comply with IPC standard to conduct temperature and humidity control. As packaging materials such as the carrier tape can only withstand the temperature of 55 °C, modules shall be removed from the package during baking.

Figure 5-2 UM960 Package

Table 5-1 Package Description

Item	Description
Module Number	500 pieces/reel
Reel Size	Tray: 13" External diameter: 330 mm Internal diameter: 100 mm Width: 24 mm Thickness: 2.0 mm
Carrier Tape	Space between (center-to-center distance): 20 mm

The UM960 is rated at MSL level 3. Refer to the relevant IPC/JEDEC J-STD-033 standards for the package and operation requirements. You may access to the website www.jedec.org to get more information.

The shelf life of the UM960 module packaged in vacuum-sealed aluminum foil antistatic bags is one year.

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