INSTALLATION AND OPERATION

USER MANUAL

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UM960E

GPS/BDS/GLONASS/Galileo/QZSS All-Constellation Multi-Frequency High-Precision RTK Positioning Module

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Foreword

Applicability

This document provides the information of the hardware, package, specification and the use of Unicore UM960E modules.

Target Readers

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

Statement

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Revision History

Release	Revision History	Date
R1.0	First release.	Jul. 2025
R1.1	Changed the power consumption from 350 mW to 360mW. Removed the note about using specific command to support frequencies B2I, B1C and B2b.	Nov. 2025
R1.2	Updated vibration and shock test standards to GB/T 28046.3, ISO 16750-3	Dec. 2025
R1.3	Updated RTK_STAT pin description in Pin Definition Removed frequency band B2I Updated Technical Specifications	Aug. 2026

Document Status

Releases	Status Descriptions	Current Status
Primary	This is a pre-release version with target specifications that are subject to revision.	
Alpha release	This is an alpha release version, which has been preliminarily tested and verified. The content may undergo minor modifications based on user feedback and further testing.	
Production release	The document contains the complete and final specifications.	√

1 Introduction

This chapter introduces the basic information of the UM960E module, including:

- Product descriptions
- Key features
- Technical specifications
- Block diagram

1.1 Product Descriptions

UM960E is Unicore's new generation GNSS all-constellation multi-frequency high-precision RTK positioning module. It is based on Unicore's proprietary GNSS SoC – NebulasIV^{TM}, which integrates RF, baseband and high-precision algorithm. For more information on NebulasIV^{TM}, see Block Diagram.

UM960E is mainly used in lawn mowers, UAVs, handheld devices, high-precision GIS, precise agriculture and intelligent drive.

UM960E features a compact size of 16.0 mm × 12.2 mm. It adopts SMT pads and supports standard pick-and-place and fully automated integration of reflow soldering.

UM960E supports interfaces such as UART and I^{2}C[1] to meet customers' needs in different applications.

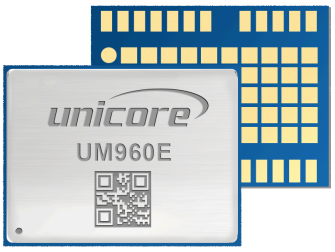


Figure 1-1 UM960E Module

1.2 Key Features

The key features of the UM960E are listed as follows:

- High precision, low power consumption, compact size
- Based on the new generation GNSS SoC – NebulasIV^{TM}, which integrates RF, baseband and high-precision algorithm

- 16.0 mm × 12.2 mm × 2.6 mm, surface-mount device
- Supports all-constellation multi-frequency on-chip RTK positioning solution
- All-constellation multi-frequency RTK engine and advanced RTK processing technology
- Independent tracking of different frequencies and 60 dB narrowband anti-jamming technology
- Advanced technology of jamming detection

For more information on the GNSS signals supported by UM960E, see Technical Specifications.

1.3 Technical Specifications

This section introduces the technical specifications of the UM960E module, including the constellations, frequencies, positioning accuracy, etc. For more information, see Table Technical Specifications.

Table 1-1 Technical Specifications

Basic Information	
Channels	1408 channels, based on NebulasIV™
Constellations	GPS, BDS, GLONASS, Galileo, QZSS
Frequencies	GPS: L1C/A, L2P(Y)/L2C, L5 BDS: B1I, B3I, B1C, B2a, B2b GLONASS: G1, G2 Galileo: E1, E5a, E5b, E6 QZSS: L1C/A, L2C, L5
Power	
Voltage	+3.0 V~3.6 V DC
Power Consumption	360 mW (Typical)
Performance	
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
Time Pulse Accuracy (RMS)	20 ns
Velocity Accuracy (RMS)	0.03 m/s
Sensitivity	Acquisition: -147 dBm Tracking: -159 dBm
Time to First Fix (TTFF)	Cold Start ≤ 35 s
Initialization Time	< 5 s (Typical)
Initialization Reliability	> 99.9%
Data Update Rate	20 Hz Positioning
Differential Data	RTCM 2.3 RTCM 3.x
Data Format	NMEA-0183 Unicore
Observation Accuracy (RMS)	Pseudorange: 10 cm Carrier Phase: 1 mm
Physical Specifications	
Package	24 pin LGA
Dimensions	16.0 mm × 12.2 mm × 2.6 mm
Weight	1.08 g ± 0.03 g
Environmental Specifications	
Operating Temperature	-40 °C~+85 °C
Storage Temperature	-55 °C~+95 °C
Humidity	95% No Condensation
Vibration	GB/T 28046.3，ISO 16750-3
Shock	GB/T 28046.3，ISO 16750-3
Functional Ports	
UART	x 3
I^2C*	x 1

*： I^2C is a reserved interface, not supported currently.

1.4 Block Diagram

This section introduces the overall structure of the UM960E module, mainly including the RF part, GNSS SoC and external interfaces.

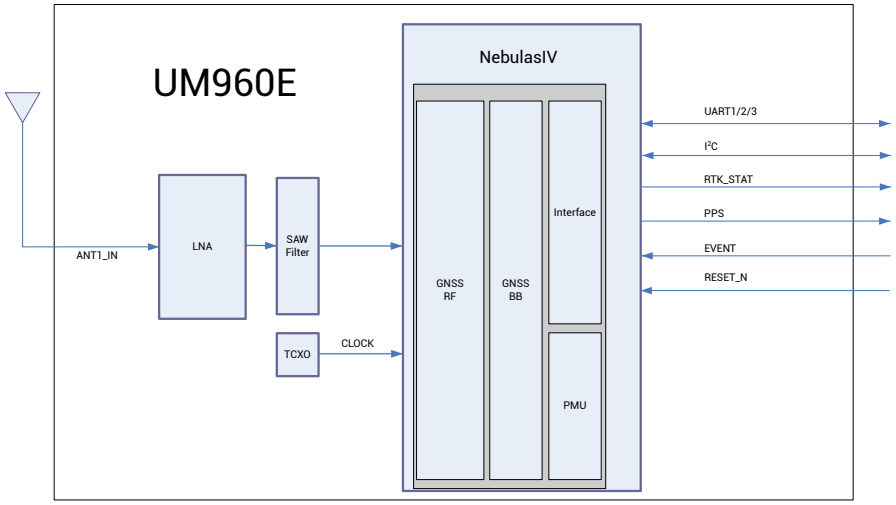


Figure 1-2 UM960E Block Diagram

(1) RF Part

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

(2) NebulasIV ™ SoC

NebulasIV™ is Unicore's new generation GNSS SoC that integrates RF, baseband and high-precision algorithm. It has the following features:

- 22 nm low power design,
- 1408 channels,
- integrating dual CPUs, a high speed floating point processor and an RTK co-processor,
- fulfilling high-precision baseband processing and RTK positioning on a single SoC.

(3) External Interfaces

UM960E has the following interfaces for external communication:

- UART
- I^2C[1:1]
- PPS

- RTK_STAT
- EVENT
- RESET_N

> **NOTE:** RTC is not supported currently.

2 Hardware

This chapter introduces the hardware information of the UM960E module, including:

- Pin definition
- Electrical specifications
- Dimensions

2.1 Pin Definition

The UM960E module has 24 pins. Figure UM960E Pin Definition is the pin definition and Table UM960E Pin Descriptions is the description of the pin functions.

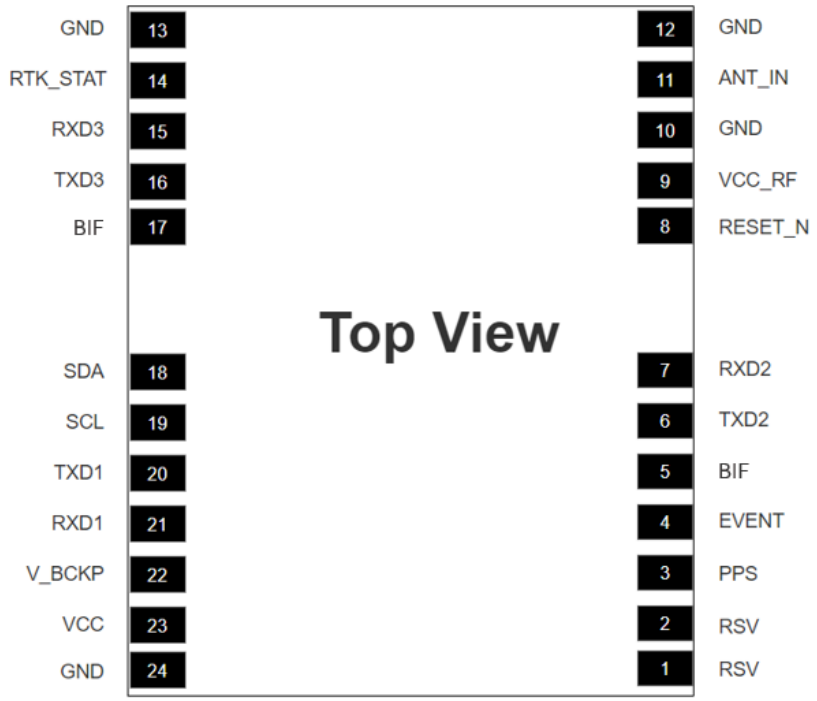


Figure 2-1 UM960E Pin Definition

Table 2-1 UM960E Pin Descriptions

No.	Pins	I/O	Descriptions
1	RSV	/	Reserved, must be floating, cannot be connected to ground or power supply or peripheral I/O.
2	RSV	/	Reserved, must be floating, cannot be connected to 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	BIF	/	Built-in function, recommended to add a through-hole test point and a 10 kΩ pull-up resistor, cannot be connected to ground or power supply or peripheral I/O, can be floating.
6	TXD2	O	UART2 output
7	RXD2	I	UART2 input
8	RESET_N	I/O	System reset. During the power-on and power-off stages, RESET_N is configured as an output and outputs a low-level pulse of 1 to 3 ms. When RESET_N is outputting low level while an external source is inputting high level, the sink current capability of RESET_N does not exceed 10 mA. After power-on is complete and during normal operation, RESET_N is configured as an input and is active low. The active time must be no less than 5 ms.
9	VCC_RF[2]	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	RTK positioning status indicator, showing current positioning status: RTK: LED on for 0.25 s, off for 0.25 s, repeating; DGPS: LED on for 1 s, off for 1 s, repeating; Single: LED on for 3 s, off for 3 s, repeating;

No.	Pins	I/O	Descriptions
			FixedPos: LED on for 10 s, off for 10 s, repeating; Other cases: LED off or constantly on.
15	RXD3	I	UART3 input
16	TXD3	O	UART3 output
17	BIF	/	Built-in function, recommended to add a through-hole test point and a 10 kΩ pull-up resistor, cannot be connected to ground or power supply or peripheral I/O, can be floating.
18	SDA	I/O	I2C data
19	SCL	I/O	I2C clock
20	TXD1	O	UART1 output
21	RXD1	I	UART1 input
22	V_BCKP[3]	I	When the main power supply VCC is cut off, V_BCKP supplies power to RTC and relevant registers. Level requirement: 2.0 V ~ 3.6 V. When the temperature is 25 °C and VCC is cut off, the working current of V_BCKP is less than 60 μA. If hot start is not used, V_BCKP should be connected to VCC. Do NOT connect it to ground or leave it floating.
23	VCC	I	Supply voltage
24	GND	/	Ground

2.2 Electrical Specifications

This section introduces the electrical specifications of the UM960E module, including:

- Absolute maximum ratings
- Operating conditions
- IO threshold
- Antenna features

2.2.1 Absolute Maximum Ratings

Table 2-2 Absolute Maximum Ratings

Parameters	Symbols	Min.	Max.	Units
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
Antenna RF Input Power	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 Operating Conditions

Parameters	Symbols	Min.	Typ.	Max.	Units	Conditions
Power Supply (VCC)	VCC	3.0	3.3	3.6	V	/
Maximum Ripple Voltage	V_{rpp}	0	/	50	mV	/
Working Current[4]	I_{opr}	/	109	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	/	360	/	mW	/

2.2.3 IO Threshold

Table 2-4 IO Threshold

Parameters	Symbols	Min.	Typ.	Max.	Units	Conditions
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 Features

Table 2-5 Antenna Features

Parameters	Symbols	Min.	Typ.	Max.	Units	Conditions
Optimum Input Gain	G_{ant}	18	27	36	dB	/

2.3 Dimensions

This sections introduces the dimensional information of the UM960E module, such as the length, width, thickness, etc.

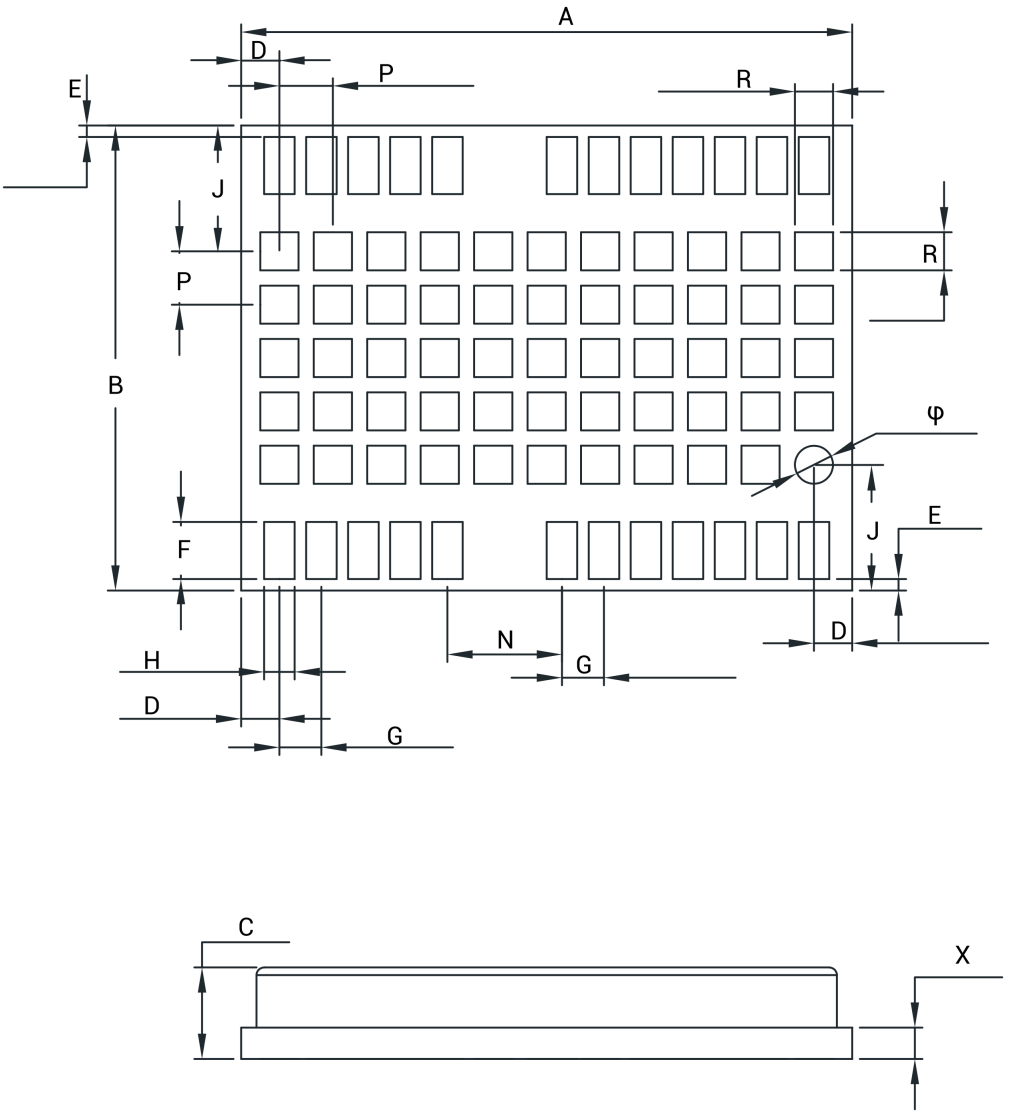


Figure 2-2 UM960E Mechanical Dimensions

Table 2-6 UM960E Mechanical Dimensions

Symbols	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

3 Hardware Design

This chapter introduces the hardware design of the UM960E module, including:

- Recommended minimal design
- Antenna bias
- Power on and power off
- Grounding and heat dissipation
- Recommended footprint on the PCB

3.1 Recommended Minimal Design

This section introduces the recommended minimal design with the UM960E module, including the schematic diagram and recommended inductors, capacitors, resistors, etc.

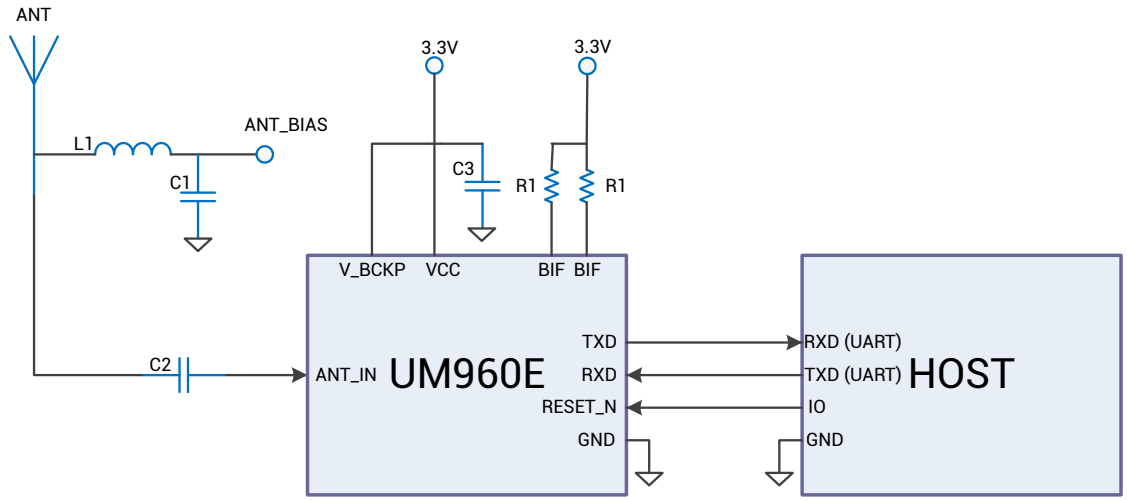


Figure 3-1 UM960E Minimal Design

Table 3-1 Descriptions of the Recommended Minimal Design

Symbols	Descriptions
L1	68 nH RF inductor in 0603 package.
C1	Two capacitors of 100 nF + 100 pF connected in parallel.
C2	100 pF capacitor.
C3	n × 10 μF + 1 × 100 nF capacitors connected in parallel, and the total capacitance should be no less than 30 μF.
R1	10 kΩ resistor.

> **NOTE:** The reset signal issued by the HOST is recommended to control only the UM960E module.

3.2 Antenna Bias

UM960E does not support internal power supply to the antenna and requires external power supply.

In order to protect the module from lightning strikes and surges, the following measures are recommended:

- Select devices with high voltage and high power capabilities.
- Add high-power protective devices such as gas discharge tubes, varistors and TVS diodes to the circuit.

> **CAUTION:**
>
> The antenna bias (ANT_BIAS) and the module's main power supply (VCC) should use separate power rails to reduce the risk of damage to the module. If ANT_BIAS and VCC use the same power rail, ESD, surge and overvoltage generated at the antenna will be directly applied to VCC, which may cause damage to the module.

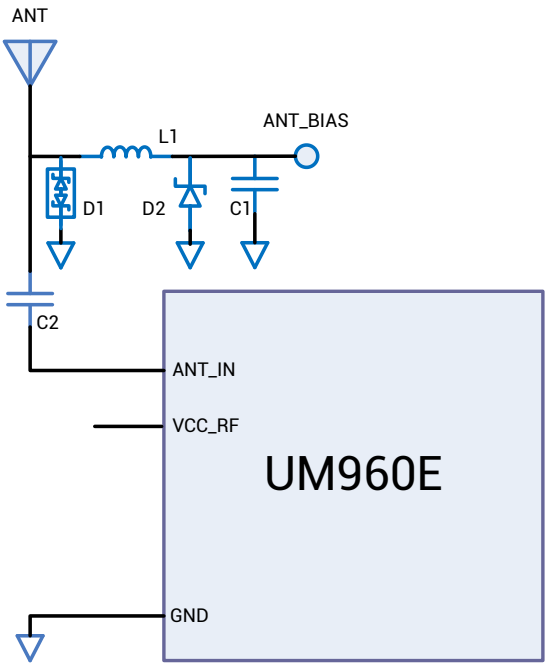


Figure 3-2 UM960E Reference Design for Antenna Bias

Table 3-2 Descriptions of the Reference Circuit

Symbols	Descriptions
L1	Feed inductor, 68nH RF inductor in 0603 package.
C1	Decoupling capacitors, two capacitors of 100nF + 100pF connected in parallel.
C2	DC blocking capacitor, 100pF.
D1	ESD diode, choose one that supports high frequency signals (above 2000 MHz).
D2	TVS diode, choose one with appropriate clamping specifications according to the supply voltage and the antenna withstand voltage.
VCC_RF	VCC_RF is not recommended to be used as ANT_BIAS to supply the antenna because it has not been optimized for anti-lightning strikes and anti-surges due to the compact size of the module.

3.3 Power-on and Power-off

The power-on and power-off requirements for the UM960E module are as follows:

(1) VCC

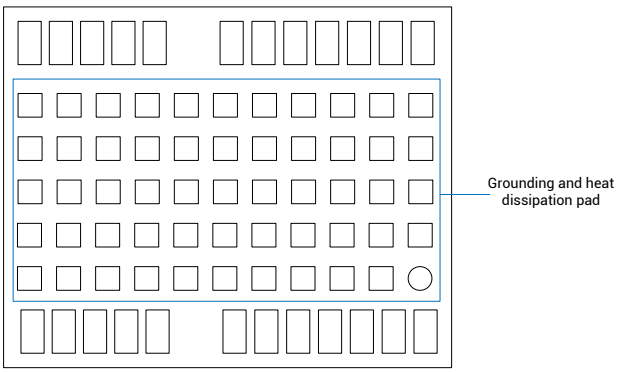
- The initial level when powered on needs to be less than 0.4 V.
- The power-on ramp needs to be monotonic, without plateaus.
- The undershoot and ringing when powered on needs to be within 5% of VCC.
- The time interval between the power-off (VCC < 0.4 V) to the next power-on needs to be larger than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

(2) V_BCKP

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

3.4 Grounding and Heat Dissipation

There are 55 pads in the rectangle area, as shown in Figure Grounding and Heat Dissipation Pads (Bottom View), which are used for grounding and heat dissipation. In PCB design, these pads should be connected to a large-sized ground to strengthen heat dissipation.



Grounding and Heat Dissipation Pads (Bottom View)

UM960E 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, please pay attention to the following recommendations during PCB design:

- Increase the number of the PCB layers. At least 4 layers are required. 6-layered PCB is recommended.
- Use at least 1 oz copper thickness on the top and bottom layers.
- 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 of 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.
- 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.
- 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 Footprint on the PCB

The dimensions of UM960E's footprint on the PCB is recommended to be the same as that of the module's pads, as shown in Figure Recommended Footprint (Unit: mm). For more information about the module's dimensions, see Dimensions.

> **NOTE:**
>
> For the convenience of hardware testing and debugging, proper test points can be added for the functional pins of the module.
>
> The dimensions of PCB pads can be optimized according to the specific production process to ensure manufacturability and reliability.

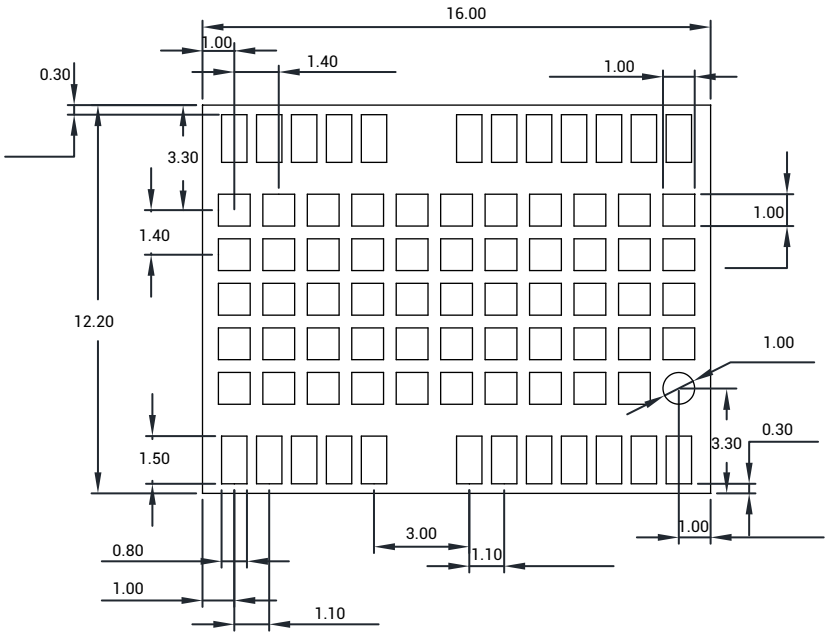


Figure 3-3 Recommended Footprint (Unit: mm)

4 Production Requirements

This chapter introduces the recommended soldering temperature and stencil design suggestions.

4.1 Soldering

Figure Soldering Temperature (Lead-Free) shows a recommended lead-free soldering temperature curve and Table Descriptions of the Soldering Temperature provides detailed descriptions.

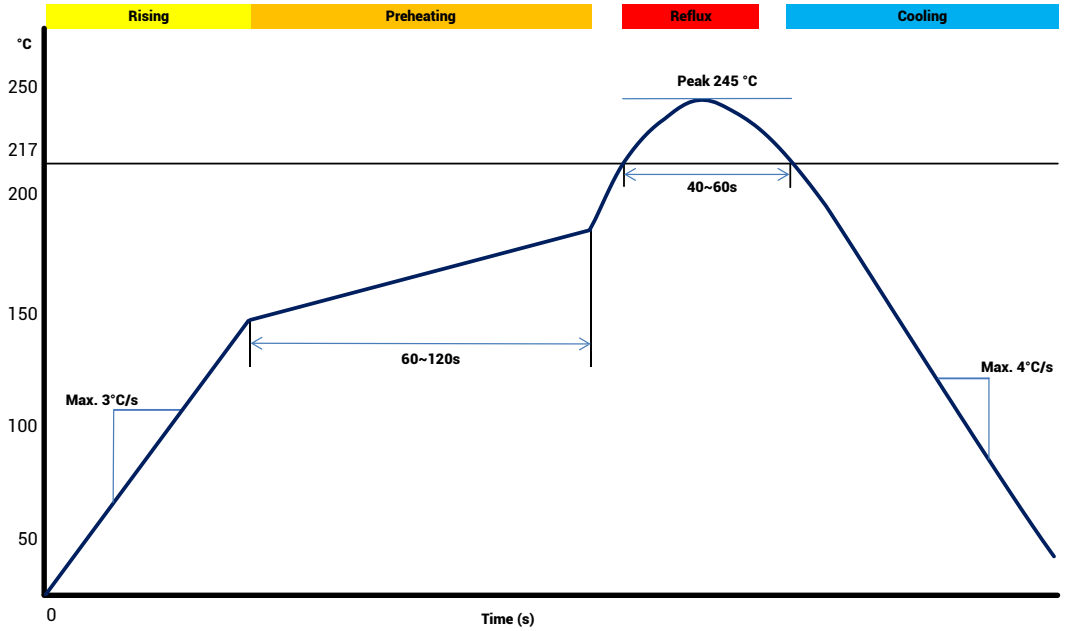


Figure 4-1 Soldering Temperature (Lead-Free)

Table 4-1 Descriptions of the Soldering Temperature

Stages	Descriptions
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

NOTE:

- In order to prevent the module from falling off during soldering, do not solder it on the back of the board, and better not go through the soldering cycle twice.
- The setting of the soldering temperature depends on many factors of the factory, such as the board type, solder paste type, solder paste thickness, etc. Please refer to the relevant IPC standards and indicators of the solder paste.
- Since the lead soldering temperature is relatively low, if using this method, please give priority to other components on the board.

4.2 Stencil

The apertures in the stencil need to meet the customer's own design requirements and inspection specifications. The thickness of the stencil is recommended to be 0.15 mm (not less than 0.12 mm).

NOTE:

The design of the stencil can be optimized according to the specific production process to ensure manufacturability and reliability.

5 Packaging

This chapter introduces the label and packaging information of the UM960E module.

5.1 Label Description

The description of the label on UM960E is shown in Figure Label Description.



Figure 5-1 Label Description

5.2 Product Packaging

(1) Package Description

The UM960E modules are surface mount devices and delivered on tape and reel, packaged in vacuum-sealed aluminum foil antistatic bags, with desiccant inside to prevent moisture.

The shelf life of the UM960E modules packaged in vacuum-sealed aluminum foil antistatic bags is 1 year.

> **CAUTION:**
>
> Please remove the modules from the package during baking, because the packaging materials such as the carrier tape can only withstand an upper temperature limit of 55 °C.



Figure 5-2 UM960E Package

Table 5-1 UM960E Package Description

Items	Descriptions
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

(2) Moisture Sensitivity Level

The UM960E module is rated at MSL level 3. Please refer to the relevant IPC/JEDEC J-STD-033 standards for the package and operation requirements. For more information, visit the website JEDEC.

1. I^2C is a reserved interface, not supported currently. ↩ ↩
2. Not recommended to use VCC_RF as ANT_BIAS to feed the antenna. See Antenna Bias for more details. ↩
3. V_BCKP is not supported currently. ↩
4. 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. ↩

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