INSTALLATION AND OPERATION

USER MANUAL

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UM981

BDS/GPS/GLONASS/Galileo/QZSS

All-constellation Multi-frequency RTK/INS Integrated Positioning Module

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Revision History

Version	Revision History	Date
R1.0	First release	Sept. 2023

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Foreword

This document describes the hardware information, specifications, packaging and the use of Unicore UM981 modules.

Target Readers

This document is written for technicians who are familiar with GNSS modules.

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1 Introduction

UM981 is a new generation of GNSS high precision RTK/INS integrated positioning module from Unicore. It supports BDS/GPS/GLONASS/Galileo/QZSS all constellations and can simultaneously track BDS B1I/B2I/B3I/B1C/B2a/B2b, GPS L1/L2/L5, GLONASS G1/G2/G3, Galileo E1/E5a/E5b/E6, QZSS L1/L2/L5, NavIC L5 and SBAS. The module is mainly used in surveying and mapping, intelligent driving*, precision agriculture, etc.

UM981 is based on NebulasIV™, a GNSS SoC which integrates the 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. It is processed with 22 nm low power design and supports 1408 channels, being able to output 100 Hz IMU raw data and up to 50 Hz* RTK positioning result, providing powerful data processing ability.

With the built-in JamShield anti-jamming technology, UM981 has improved the performance of RTK solution for multiple modes and frequencies, ensuring fast RTK initialization speed, high accuracy of measurement and high reliability even in the most challenging environments such as urban canyons and tree shades.

Furthermore, UM981 supports various interfaces such as UART, I²C*, SPI*, as well as 1PPS, EVENT, CAN*, which meets customers' needs in different applications.

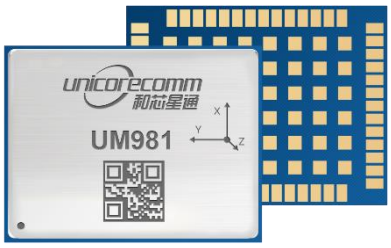


Figure 1-1 UM981 Module

* The application marked with an asterisk is supported by customized model or firmware.

* Data update rate can reach 50 Hz after firmware upgrade.

* I²C, SPI, CAN: reserved interfaces, not supported currently

1.1 Key Features

- Based on the new generation GNSS SoC - NebulasIV™, which integrates RF-baseband and high precision algorithm
- 17 mm × 22 mm × 2.6 mm, surface-mount device
- Supports all-constellation multi-frequency on-chip RTK positioning solution
- Supports BDS B1I/B2I/B3I/B1C/B2a/B2b + GPS L1/L2/L5 + GLONASS G1/G2/G3 + Galileo E1/E5a/E5b/E6 + QZSS L1/L2/L5 + NavIC L5 + SBAS
- All-constellation multi-frequency RTK engine and advanced RTK processing technology
- Instantaneous RTK initialization technology
- Independent tracking of different frequencies and 60 dB narrowband anti-jamming technology
- 100 Hz IMU raw data output and up to 50 Hz* RTK positioning result output

1.2 Key Specifications

Table 1-1 Technical Specifications

Basic Information	
Channels	1408 channels, based on NebulasIV™
Constellations	BDS/GPS/GLONASS/Galileo/QZSS
Frequencies	BDS: B1I, B2I, B3I, B1C, B2a, B2b GPS: L1 C/A, L1C, L2P (Y), L2C, L5 GLONASS: G1, G2, G3 Galileo: E1, E5a, E5b, E6 QZSS: L1, L2, L5 NavIC: L5
Power	
Voltage	+3.0 V ~ +3.6 V DC
Power Consumption	480 mW (Typical)

Performance				
Positioning Accuracy	Single Point Positioning[1] (RMS)	Horizontal: 1.5 m		
		Vertical: 2.5 m		
	DGPS (RMS)[1,2]	Horizontal: 0.4 m		
		Vertical: 0.8 m		
	RTK (RMS)[1,2]	Horizontal: 0.8 cm + 1 ppm		
		Vertical: 1.5 cm + 1 ppm		
	Tilt Measurement	10 mm + 0.7 mm/°tilt (accuracy < 2.5 cm within 30°)		
Attitude Accuracy	Heading	0.3°		
	Roll	0.2°		
	Pitch	0.2°		
Observation Accuracy (RMS)	BDS	GPS	GLONASS	Galileo
B1I/B1C/L1C/L1 C/A/G1/E1 Pseudorange	10 cm	10 cm	10 cm	10 cm
B1I/B1C/L1C/L1 C/A/G1/E1 Carrier Phase	1 mm	1 mm	1 mm	1 mm
B3I/L2P(Y)/L2C/G2/E6 Pseudorange	10 cm	10 cm	10 cm	10 cm
B3I/L2P(Y)/L2C/G2/E6 Carrier Phase	1 mm	1 mm	1 mm	1 mm
B2I/B2a/B2b/L5/G3/E5a/E5b Pseudorange	10 cm	10 cm	10 cm	10 cm

[1] Test results may be biased due to atmospheric conditions, baseline length, GNSS antenna type, multipath effect, number of visible satellites, and satellite geometry.

[2] The measurement uses 1 km baseline and a receiver with good antenna performance, regardless of possible errors of antenna phase center offset.

B2I/B2a/B2b/L5/G3/E5a/E5b Carrier Phase	1 mm	1 mm	1 mm	1 mm
Time Pulse Accuracy (RMS)	20 ns			
Velocity Accuracy[3] (RMS)	0.03 m/s			
Time to First Fix[4] (TTFF)	Cold Start < 12 s			
	Hot Start < 4 s			
Initialization Time[1]	< 5 s (Typical)			
Initialization Reliability[1]	> 99.9%			
Data Update Rate[5]	100 Hz IMU raw data output 50 Hz RTK positioning result output			
Differential Data	RTCM 3.X			
Data Format	NMEA-0183, Unicore			
Physical Characteristics				
Package	54 pin LGA			
Dimensions	22 mm × 17 mm × 2.6 mm			
Weight	1.91 g ± 0.03 g			
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			

[3] Open sky, unobstructed scene, 99% @ static

[4] -130dBm @ more than 12 available satellites

[5] The 50 Hz data update rate is supported after firmware upgrade

Functional Ports	
UART × 3	
I²C* × 1	
SPI* × 1	Slave
CAN* × 1	Shared with UART3

1.3 Block Diagram

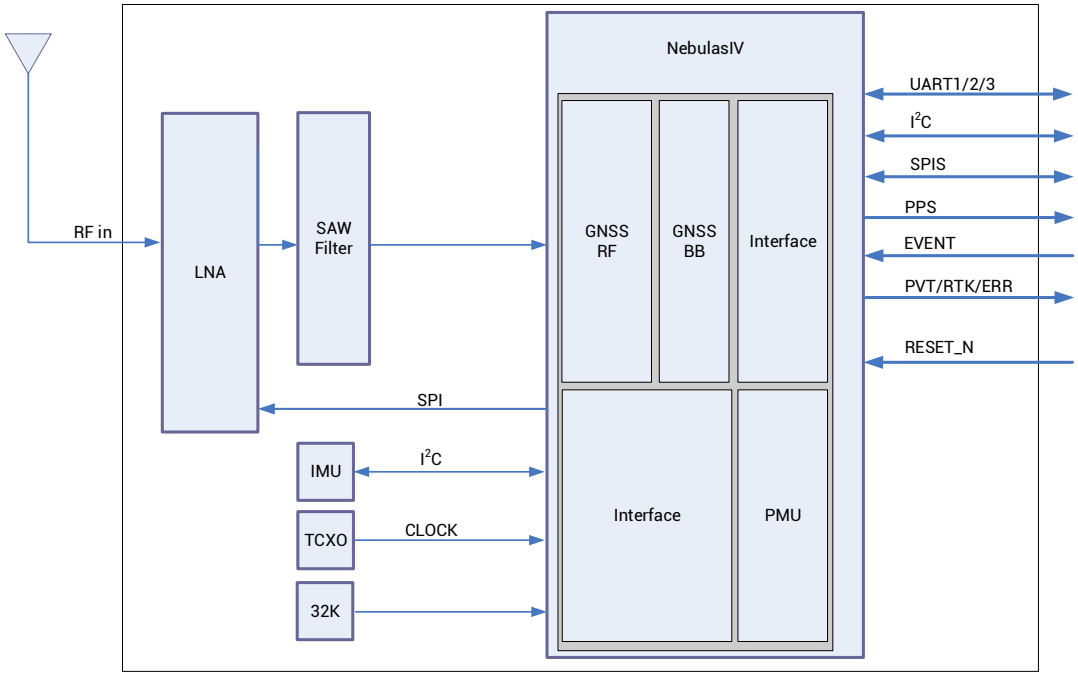


Figure 1-2 UM981 Block Diagram

- **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 signals, and converts IF analog signals into digital signals required for NebulasIV™ chip (UC9810).

- **NebulasIV™ SoC (UC9810)**

NebulasIV (UC9810) is UNICORECOMM's new generation high precision GNSS SoC with

* I²C, SPI, CAN: reserved interfaces, not supported currently

22 nm low power design, supporting all constellations and all frequencies with 1408 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 on a single chip.

- **External Interfaces**

The external interfaces of UM981 include UART, I²C*, SPI*, CAN*, PPS, EVENT, RTK_STAT, PVT_STAT, ERR_STAT, RESET_N, etc.

2 Hardware

2.1 Pin Definition

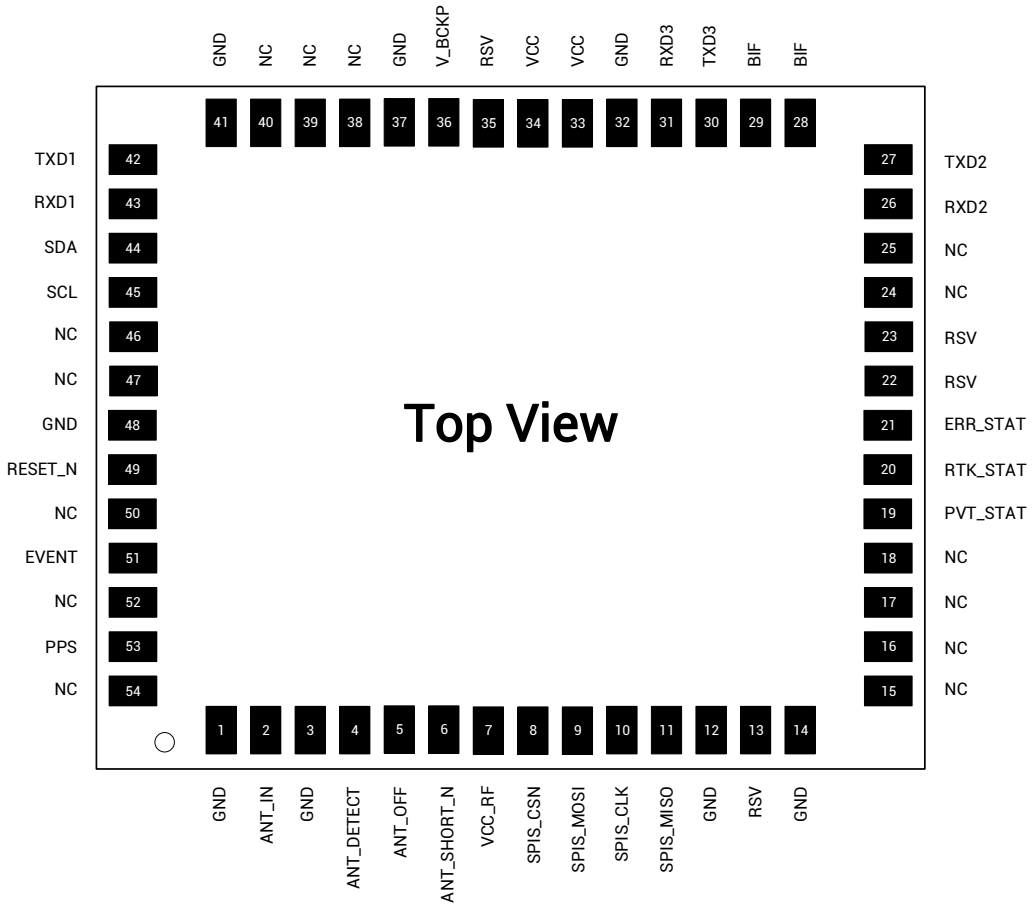


Figure 2-1 UM981 Pin Definition

* I²C, SPI, CAN: reserved interfaces, not supported currently

Table 2-1 Pin Description

No.	Pin	I/O	Description
1	GND	—	Ground
2	ANT_IN	I	GNSS antenna signal input
3	GND	—	Ground
4	ANT_DETECT	I	Antenna signal detection
5	ANT_OFF	O	Disable external LNA
6	ANT_SHORT_N	I	Antenna short circuit detection; active low
7	VCC_RF[6]	O	External LNA power supply
8	SPIS_CSN	I	Chip select pin for SPI slave
9	SPIS_MOSI	I	Master Out / Slave In. This pin is used to receive data in slave mode.
10	SPIS_CLK	I	Clock input pin for SPI slave
11	SPIS_MISO	O	Master In / Slave Out. This pin is used to transmit data in slave mode.
12	GND	—	Ground
13	RSV	—	Reserved
14	GND	—	Ground
15	NC	—	No connection inside
16	NC	—	No connection inside
17	NC	—	No connection inside
18	NC	—	No connection inside

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

No.	Pin	I/O	Description
19	PVT_STAT	O	PVT status: active high; Outputs high when positioning and low when not positioning
20	RTK_STAT	O	RTK status: active high; Outputs high for RTK fixed solution and low for other positioning status or no positioning
21	ERR_STAT	O	Error status: active high; Outputs high when failing self-test and low when passing self-test
22	RSV	—	Reserved, recommended to be floating
23	RSV	—	Reserved, recommended to be floating
24	NC	—	No connection inside
25	NC	—	No connection inside
26	RXD2	I	COM2 input, LVTTL
27	TXD2	O	COM2 output, LVTTL
28	BIF	—	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 input/output data, but can be floating
29	BIF	—	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 input/output data, but can be floating
30	TXD3	O	COM3 output, can be used as CAN TXD, LVTTL
31	RXD3	I	COM3 input, can be used as CAN RXD, LVTTL
32	GND	—	Ground

No.	Pin	I/O	Description
33	VCC	I	Power supply
34	VCC	I	Power supply
35	RSV	—	Reserved
36	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.
37	GND	—	Ground
38	NC	—	No connection inside
39	NC	—	No connection inside
40	NC	—	No connection inside
41	GND	—	Ground
42	TXD1	O	COM1 output, LVTTL
43	RXD1	I	COM1 input, LVTTL
44	SDA	I/O	I^2C data
45	SCL	I/O	I^2C clock
46	NC	—	No connection inside
47	NC	—	No connection inside
48	GND	—	Ground
49	RESET_N	I	System reset; active Low. The active time should be no less than 5 ms.
50	NC	—	No connection inside

No.	Pin	I/O	Description
51	EVENT	I	Event mark input, with adjustable frequency and polarity
52	NC	—	No connection inside
53	PPS	O	Pulse per second, with adjustable pulse width and polarity
54	NC	—	No connection inside

2.2 Electrical Specifications

2.2.1 Absolute Maximum Ratings

Table 2-2 Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit
Power Supply Voltage	VCC	-0.3	3.6	V
Input Voltage	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

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Power Supply Voltage[7]	VCC	3.0	3.3	3.6	V	
Maximum VCC Ripple	V_{rpp}	0		50	mV	
Working Current[8]	I_{opr}		145	180	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		480		mW	

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		0.6	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} = 2 mA
High Level Output Voltage	V_{out_high}	VCC - 0.45		VCC	V	I_{out} = 2 mA

[7] The voltage range of VCC (3.0 V ~ 3.6 V) has already included the ripple voltage.

[8] 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.

2.2.4 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

Parameter	Min. (mm)	Typ. (mm)	Max. (mm)
A	21.80	22.00	22.50
B	16.80	17.00	17.50
C	2.40	2.60	2.80
D	3.75	3.85	3.95
E	0.95	1.05	1.15
F	1.80	1.90	2.00
G	1.00	1.10	1.20
H	0.70	0.80	0.90
K	1.40	1.50	1.60
M	3.55	3.65	3.75
N	3.15	3.25	3.35
P	2.00	2.10	2.20
R	1.00	1.10	1.20
X	0.72	0.82	0.92

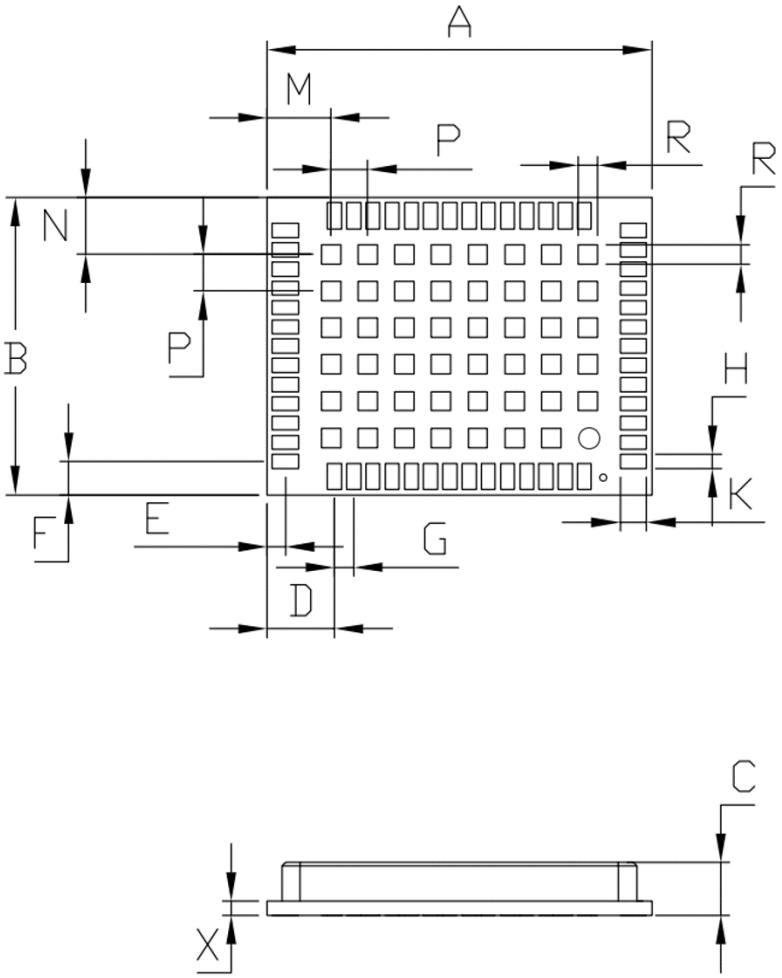


Figure 2-2 UM981 Mechanical Dimensions

3 Hardware Design

3.1 Recommended Minimal Design

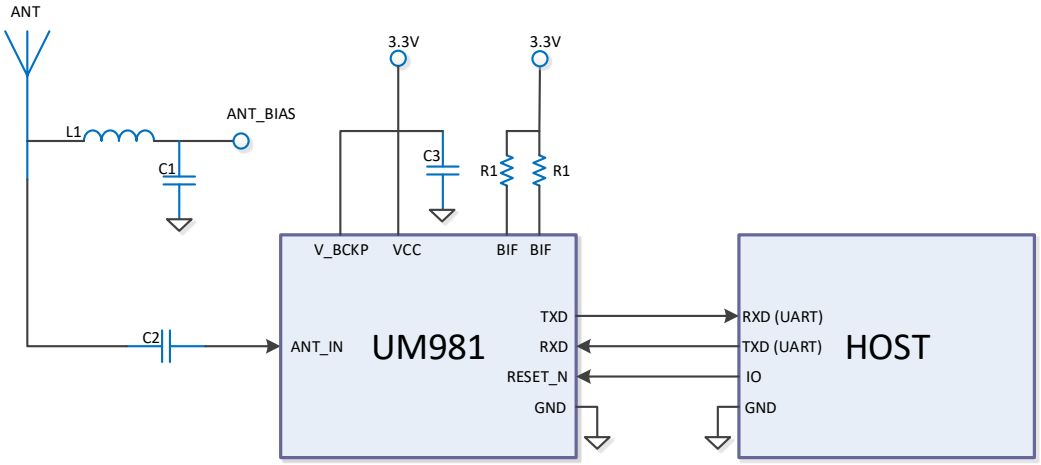


Figure 3-1 Recommended Minimal Design

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

UM981 just supports feeding the antenna from the outside of the module rather than from 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.

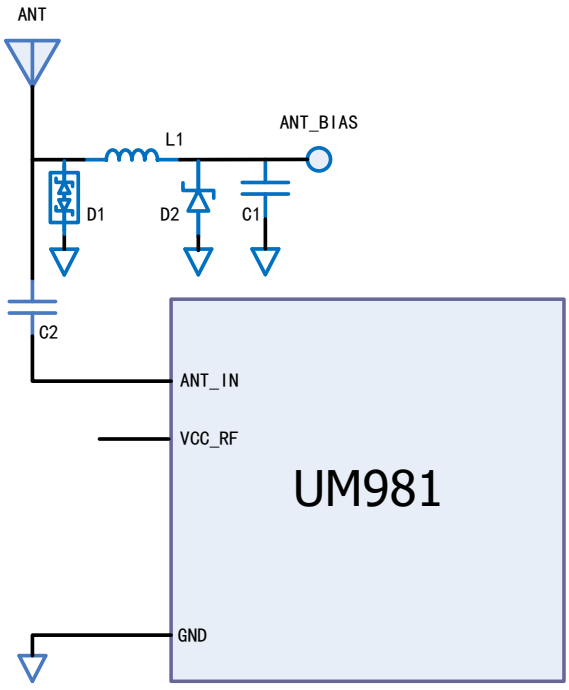


Figure 3-2 UM981 External Antenna Feed Reference Circuit

Notes:

1. L1: feed inductor, 68 nH RF inductor in 0603 package is recommended
2. C1: decoupling capacitor, recommended to connect two capacitors of 100 nF/100 pF in parallel
3. C2: DC blocking capacitor, recommended 100 pF capacitor

4. It is not recommended to take VCC_RF as ANT_BIAS to feed the antenna (VCC_RF is not optimized for anti-lightning strike, anti-surge and over current protection due to the compact size of the module)
5. D1: ESD diode, choose the ESD protection device that supports high frequency signals (above 2000 MHz)
6. D2: TVS diode, choose a TVS diode with appropriate clamping specification according to the requirement of feed voltage and the antenna withstand 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.
- VCC power-on waveform: The time interval from 10% rising to 90% must be within 100 μs ~1 ms.
- 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.
- V_BCKP power-on waveform: The time interval from 10% rising to 90% must be within 100 us ~1 ms.
- 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

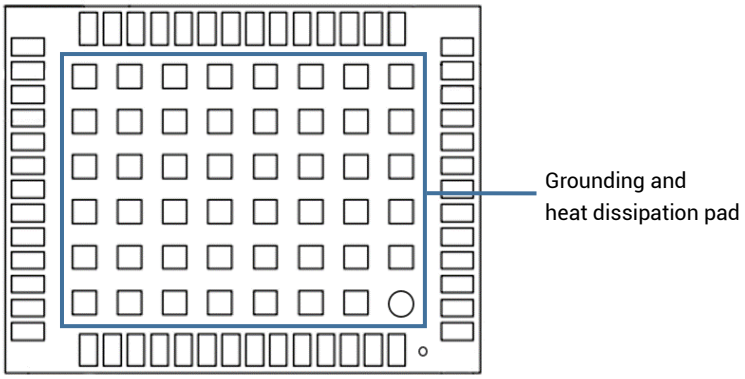


Figure 3-3 Grounding and Heat Dissipation Pad (Bottom View)

The 48 pads in the rectangle area are used for grounding and heat dissipation. In the PCB design, the pads should be connected to a large-size ground to strengthen the heat dissipation.

3.5 Recommended PCB Package Design

See the following figure for the recommended PCB package design.

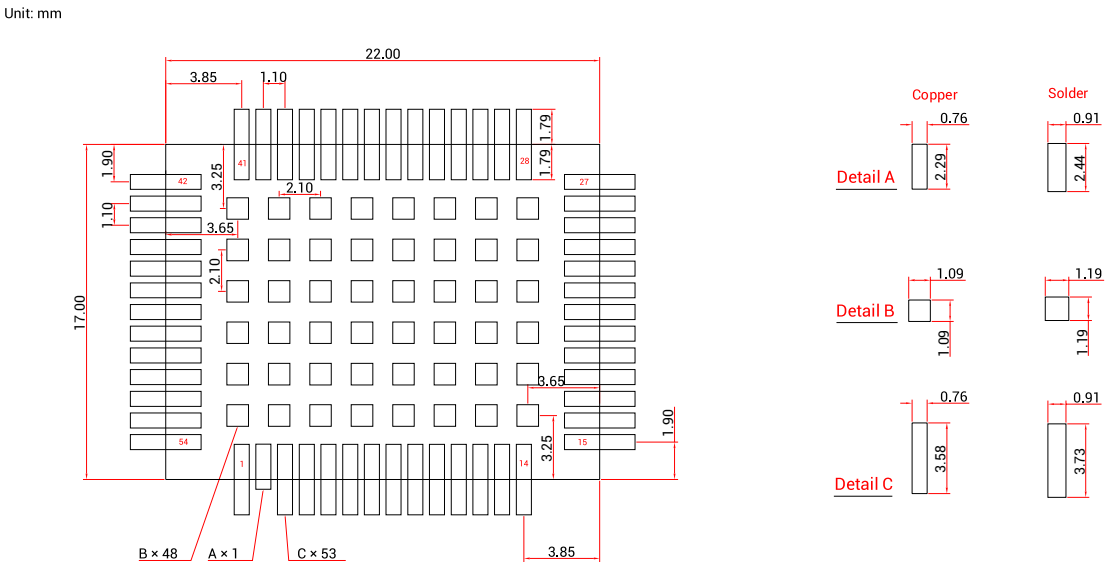


Figure 3-4 Recommended PCB Package Design

Notes:

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 1.79 mm longer than the module border.
- The pad denoted as detail A is 0.50 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 external interference on the RF signals.

4 Production Requirement

Recommended soldering temperature curve is as follows:

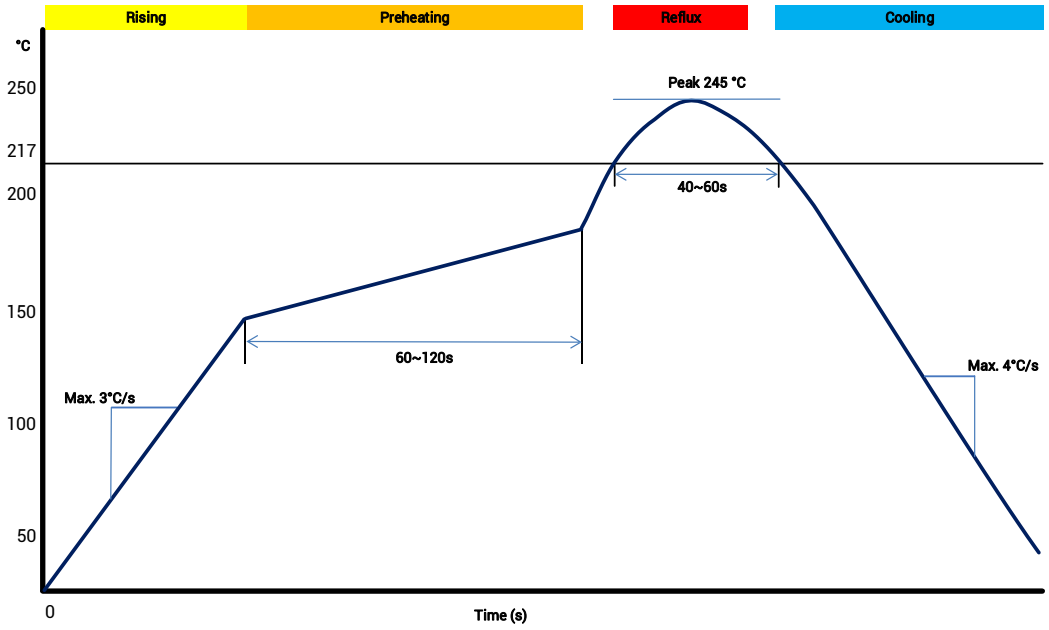


Figure 4-1 Soldering Temperature (Lead-free)

Temperature Rising Stage

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

Preheating Stage

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

Reflux Stage

- Over melting temperature (217 °C) time: 40s ~ 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, and it is not recommended to 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

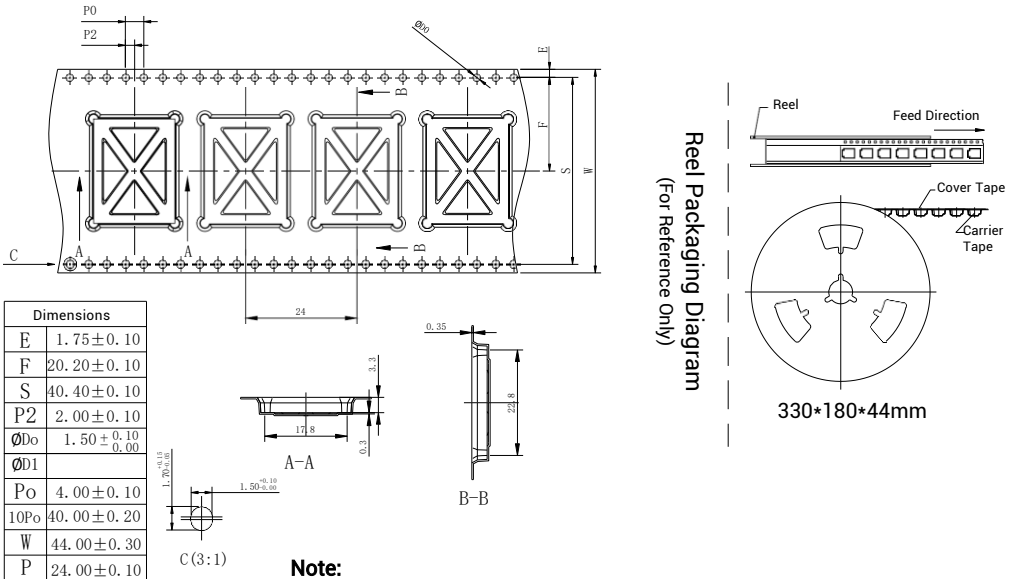
5.2 Product Packaging

The UM981 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 on the modules. As packaging materials such as the carrier tape can only withstand the

temperature of 55 degrees Celsius, modules shall be removed from the package during baking.



Figure 5-2 UM981 Package



Dimensions	
E	1.75±0.10
F	20.20±0.10
S	40.40±0.10
P2	2.00±0.10
ØDo	1.50 +0.10 0.00
ØD1	
Po	4.00±0.10
10Po	40.00±0.20
W	44.00±0.30
P	24.00±0.10
Ao	17.80±0.10
BO	22.80±0.10
KO	3.30±0.10
t	0.35±0.05

Note:

1. The cumulative tolerance of 10 side holes should not exceed ±0.2 mm.
2. Material of the tape: Black antistatic PS (surface impedance 10^5-10^{11}) (surface static voltage <100 V), thickness: 0.35 mm.
3. Total length of the 13-inch reel package: 6.816 m (Length of the first part of empty packets: 0.408 m, length of packets containing modules: 6 m, length of the last part of empty packets: 0.408 m).
4. Total number of packets in the 13-inch reel package: 284 (Number of the first part of empty packets: 17; actual number of modules in the packets: 250; number of the last part of empty packets: 17).
5. All dimension designs are in accordance with EIA-481-C-2003.
6. The maximum bending degree of the carrier tape within the length of 250 mm should not exceed 1 mm (see the figure below).

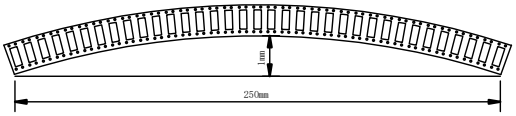


Figure 5-3 UM981 Reel Package Diagram

Table 5-1 Package Description

Item	Description
Module Number	250 pieces/reel
Reel Size	Tray: 13" External diameter: 330 ± 2 mm, Internal diameter: 180 ± 2mm, Width: 44.5 ± 0.5 mm Thickness: 2.0 ± 0.2 mm
Carrier Tape	Space between (center-to-center distance): 24 mm

Before surface mounting, make sure that the color of the 30% circle on the HUMIDITY INDICATOR is blue (see Figure 5-4). If the color of the 20% circle is pink and the color of the 30% circle is lavender (see Figure 5-5), you must bake the module until it turns to blue. The UM981 is rated at MSL level 3. Please refer to the IPC/JEDEC J-STD-033 standards for the package and operation requirements. You may also access to the website www.jedec.org to get more information.

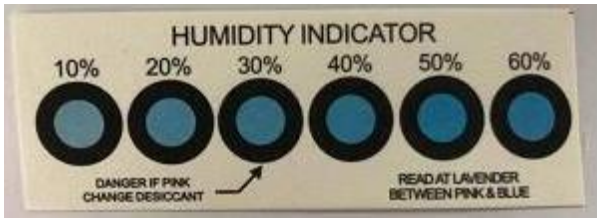


Figure 5-4 Normal Humidity Indication

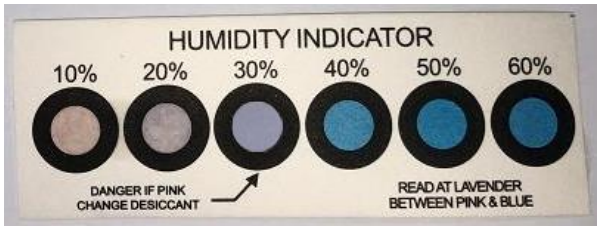


Figure 5-5 Abnormal Humidity Indication

The shelf life of the UM981 module packaged in vacuum-sealed aluminum foil antistatic bags is one year.