INSTALLATION AND OPERATION

USER MANUAL

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UM981S

BDS/GPS/GLONASS/Galileo/QZSS

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

Revision History

Version	Revision History	Date
R1.0	First release	Oct. 2024

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Foreword

This document describes the hardware information, specifications, packaging and the use of Unicore UM981S modules.

Target Readers

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

Contents

1 Introduction

UM981S is a new generation GNSS high precision RTK/INS integrated positioning module from Unicore. It can track BDS/GPS/GLONASS/Galileo/QZSS all constellations and multiple frequencies. The module is mainly used in high precision applications and is particularly suitable for surveying and mapping.

UM981S 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. It is processed with 22 nm low power design and has 1408 channels, being able to output 100 Hz IMU raw data and up to 50 Hz* RTK positioning data, providing powerful data processing ability. With the built-in JamShield anti-jamming technology, UM981S has improved the performance of multi-mode multi-frequency RTK solution, ensuring fast RTK initialization speed, high accuracy of measurement and high reliability even in signal-challenging environments such as urban canyons and tree shades. UM981S has also integrated an IMU for surveying and mapping applications, supporting tilt compensation.

UM981S has various interfaces such as UART, I²C* and SPI*, as well as 1PPS, EVENT and CAN*, which meets customers' needs in different applications.

Figure 1-1 UM981S Module

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

* I²C, SPI and CAN are 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
- All-constellation multi-frequency RTK engine and advanced RTK processing technology
- Instantaneous RTK initialization technology
- Tracking different frequencies separately with 60 dB narrowband anti-jamming technology
- 100 Hz IMU raw data output and GNSS & IMU integrated data output, up to 50 Hz* RTK positioning data output
- Supports tilt compensation

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: L1C/A, L1C, L2C, 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[1,2] (RMS)	Horizontal: 0.4 m		
		Vertical: 0.8 m		
	RTK[1,2] (RMS)	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
B2I/B2a/B2b/L5/G3/E5a/E5b Carrier Phase	1 mm	1 mm	1 mm	1 mm

[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.

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
GNSS Initialization Time[1]	< 5 s (Typical)
GNSS Initialization Reliability[1]	> 99.9%
Data Update Rate[5]	100 Hz IMU raw data output and GNSS & IMU integrated data output 50 Hz RTK positioning data 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
Functional Ports	

[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

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

1.3 Block Diagram

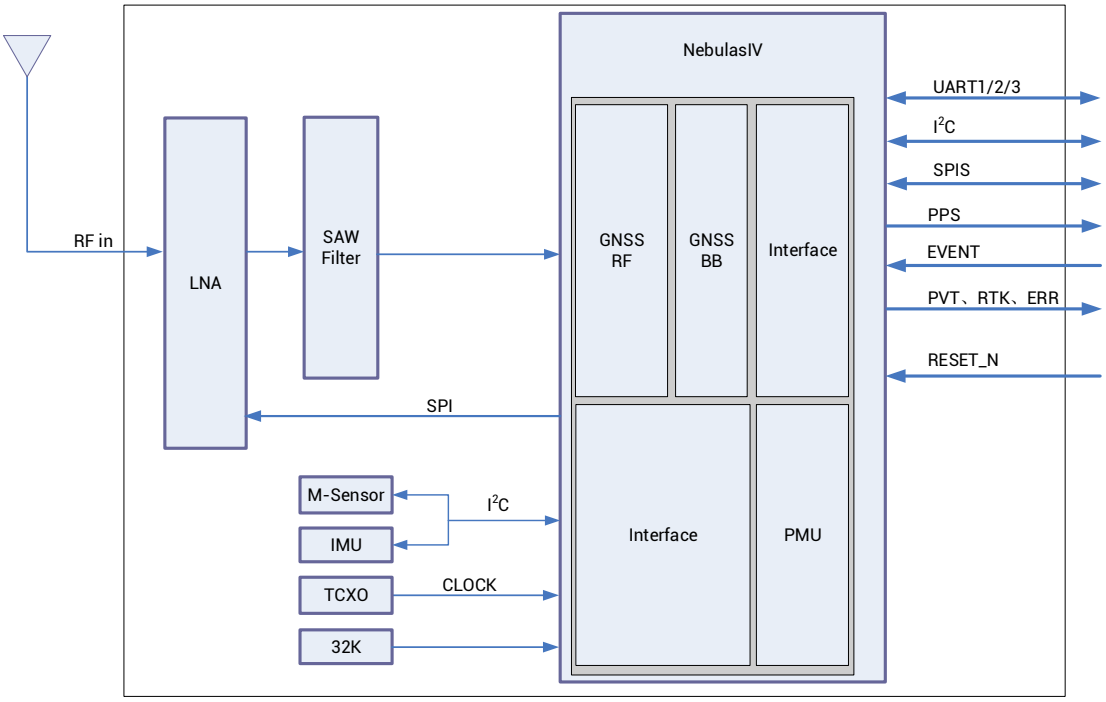


Figure 1-2 UM981S Block Diagram

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

- **NebulasIV™ SoC (UC9810)**

NebulasIV (UC9810) is Unicore's new generation high precision GNSS SoC with 22 nm low power design, supporting all constellations and all frequencies with 1408 channels.

* I²C, SPI and CAN are reserved interfaces, not supported currently.

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 UM981S include UART, I²C*, SPI*, CAN*, PPS, EVENT, RTK_STAT, PVT_STAT, ERR_STAT, RESET_N, etc.

2 Hardware

2.1 Pin Definition

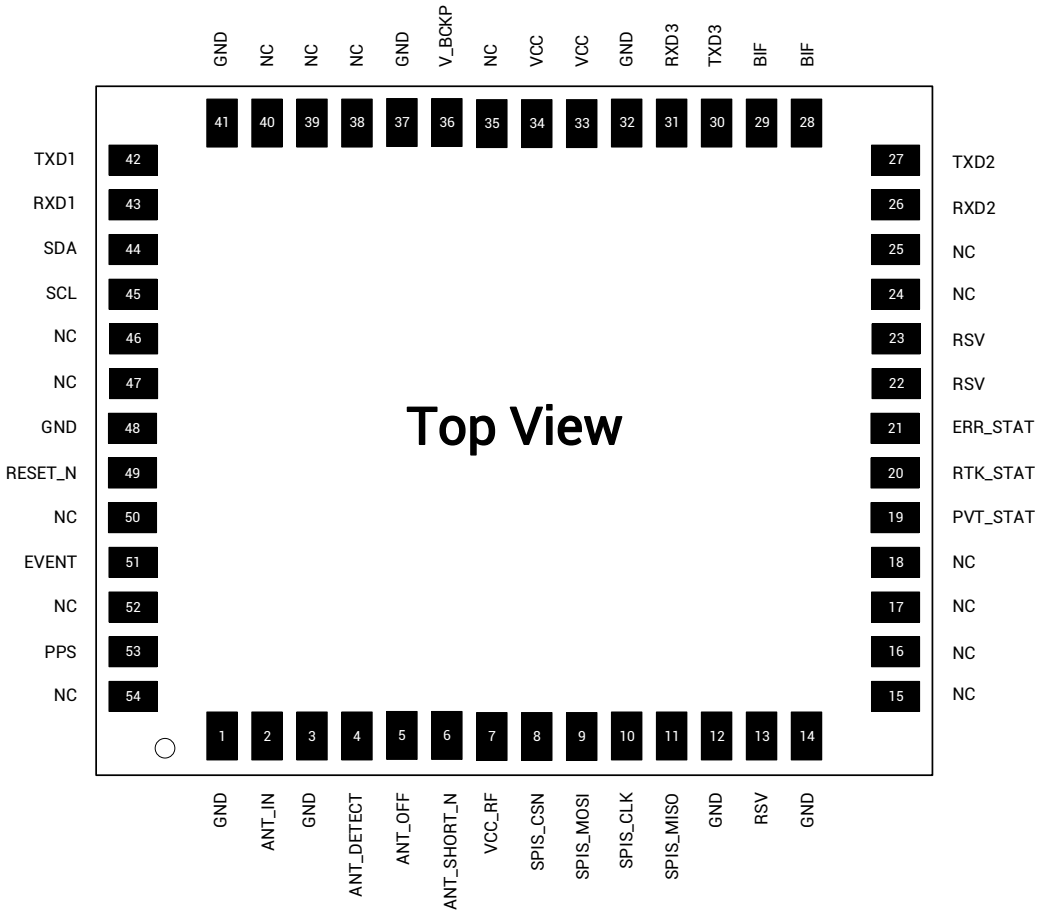


Figure 2-1 UM981S Pin Definition

* 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; must be floating
14	GND	—	Ground
15	NC	—	No connection inside; leave floating
16	NC	—	No connection inside; leave floating
17	NC	—	No connection inside; leave floating
18	NC	—	No connection inside; leave floating
19	PVT_STAT	O	PVT status: active high; Outputs high when positioning and low when not positioning

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

No.	Pin	I/O	Description
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; must be floating
23	RSV	—	Reserved; must be floating
24	NC	—	No connection inside; leave floating
25	NC	—	No connection inside; leave floating
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
33	VCC	I	Power supply
34	VCC	I	Power supply

No.	Pin	I/O	Description
35	NC	—	No connection inside; leave floating
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; leave floating
39	NC	—	No connection inside; leave floating
40	NC	—	No connection inside; leave floating
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; leave floating
47	NC	—	No connection inside; leave floating
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; leave floating
51	EVENT	I	Event mark input, with adjustable frequency and polarity
52	NC	—	No connection inside; leave floating

No.	Pin	I/O	Description
53	PPS	O	Pulse per second, with adjustable pulse width and polarity
54	NC	—	No connection inside; leave floating

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

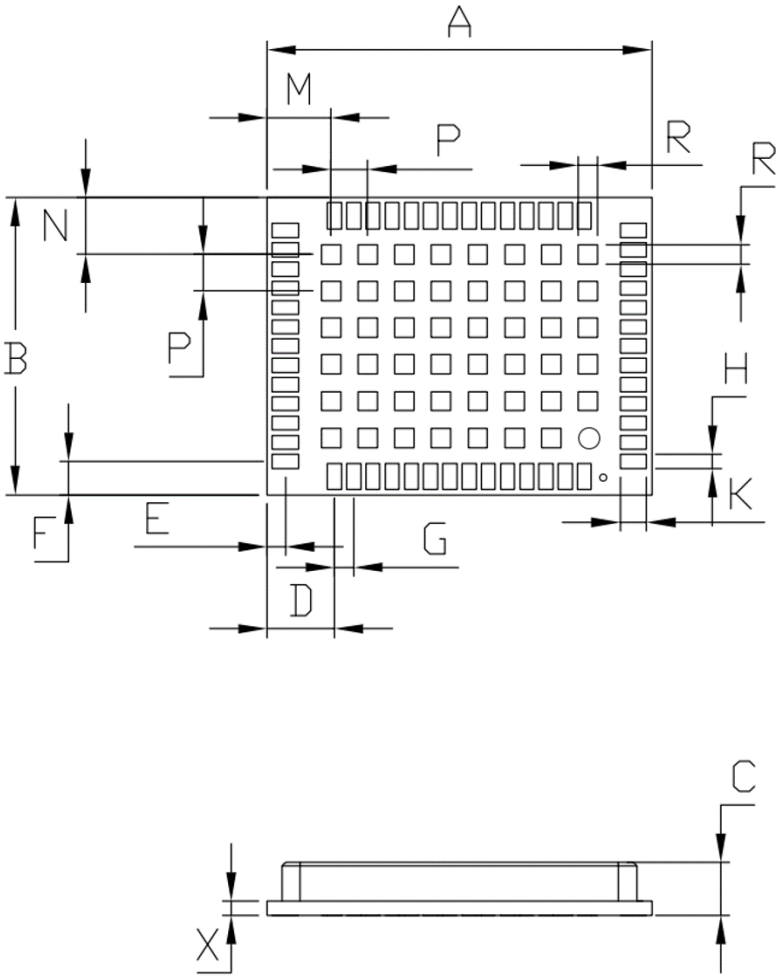


Figure 2-2 UM981S Mechanical Dimensions

3 Hardware Design

3.1 Recommended Minimal Design

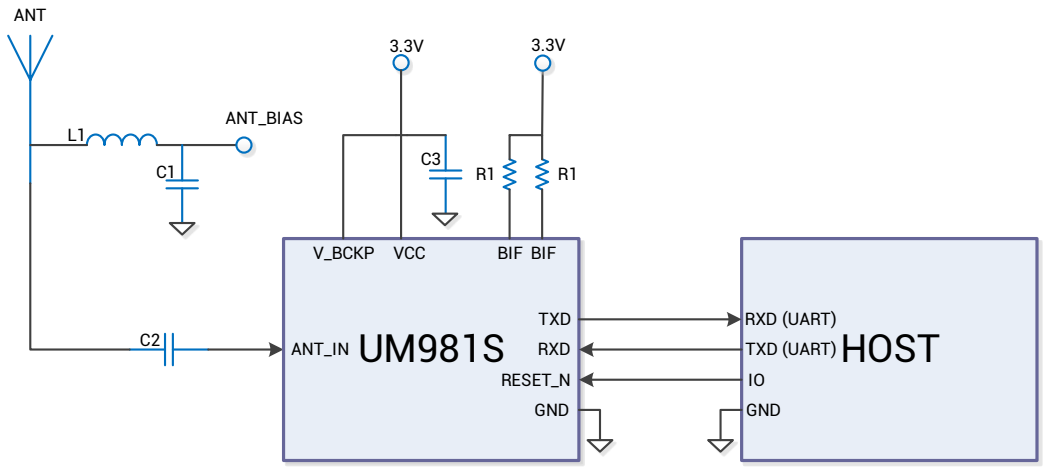


Figure 3-1 Recommended Minimal Design

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

UM981S 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.

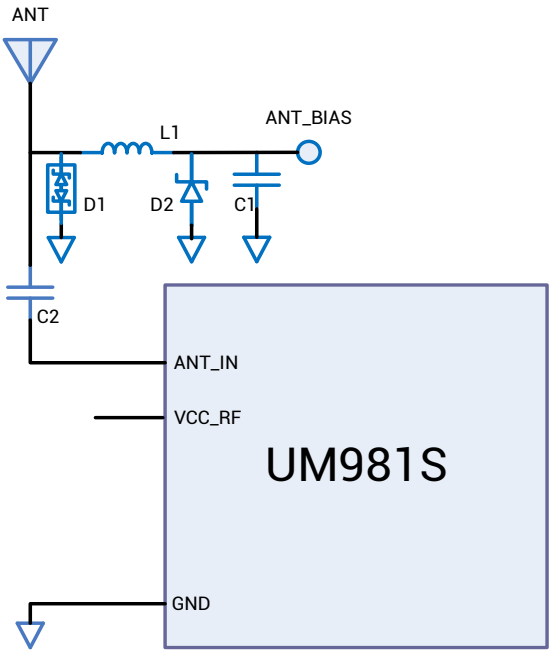


Figure 3-2 UM981S External Antenna Feed Reference Circuit

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 use VCC_RF as ANT_BIAS to feed the antenna (VCC_RF has not been 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 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.
- 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

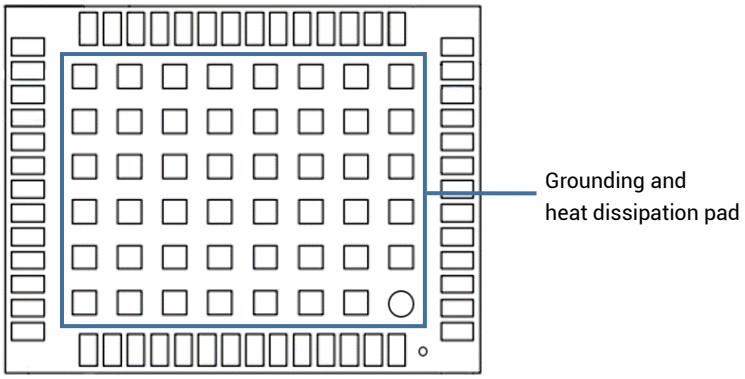


Figure 3-3 Grounding and Heat Dissipation Pad (Bottom View)

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.

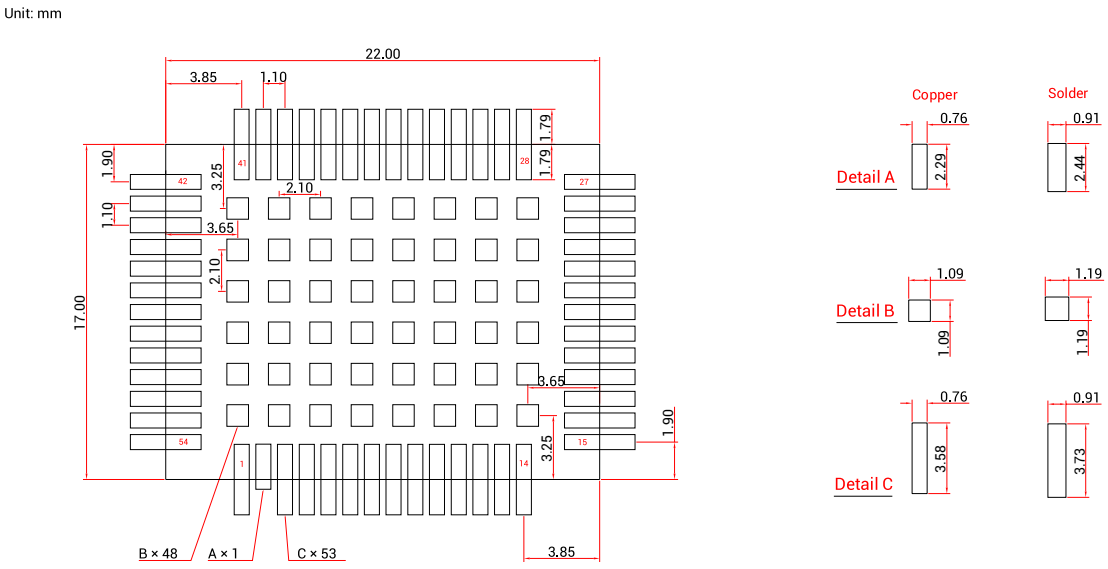


Figure 3-4 Recommended PCB Package Design

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 because 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:

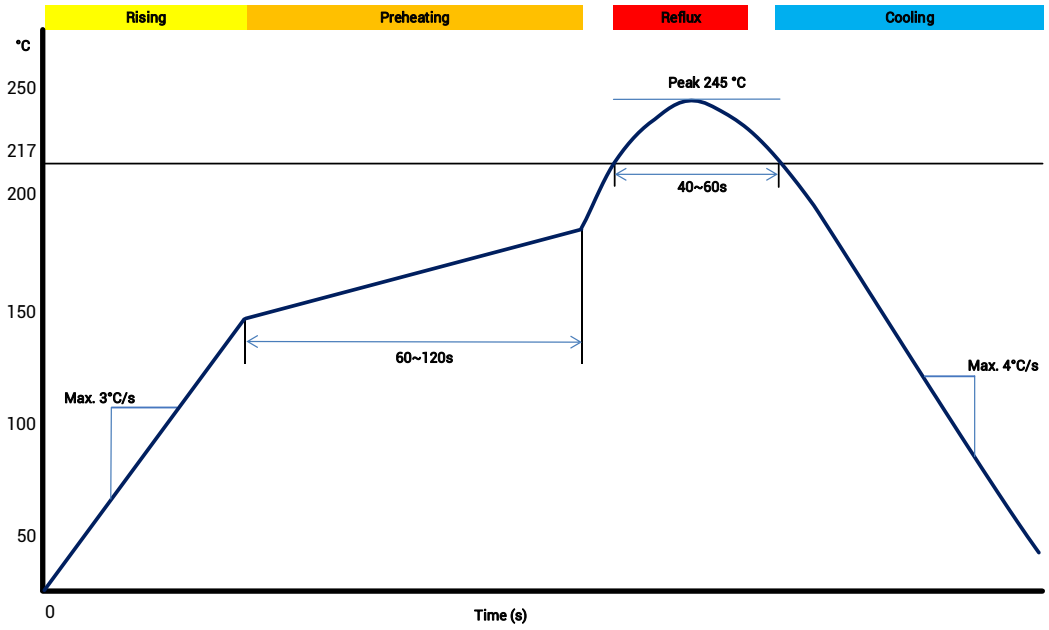


Figure 4-1 Soldering Temperature (Lead-free)

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

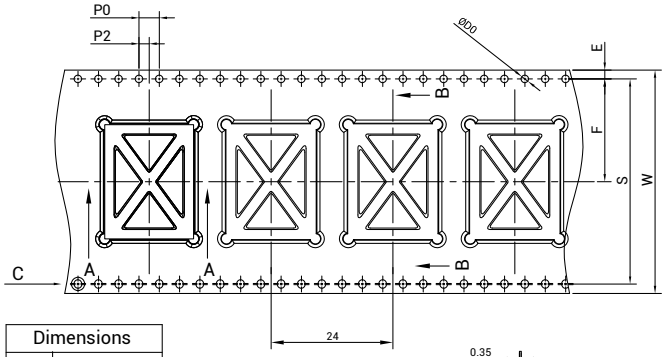
Figure 5-1 Label Description

5.2 Product Packaging

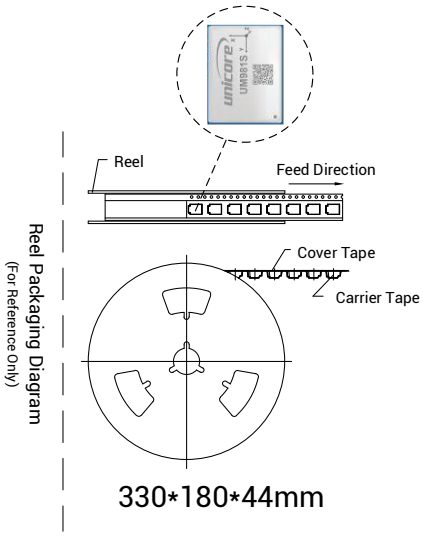
The UM981S module uses carrier tape and reel (suitable for mainstream surface mount devices), packaged in vacuum-sealed aluminum foil antistatic bags, with a desiccant inside to prevent moisture. When using reflow soldering process to solder modules, please strictly comply with IPC standard to conduct 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 UM981S Package



Dimensions	
E	1.75±0.10
F	20.20±0.10
S	40.40±0.10
P2	2.00±0.10
ØDo	$1.50 \pm \frac{0.10}{0.00}$
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
B0	22.80±0.10
K0	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).

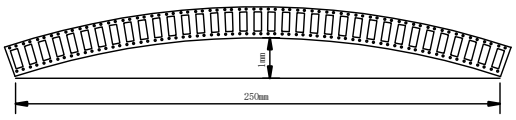


Figure 5-3 UM981S Reel Package Diagram

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 UM981S 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.

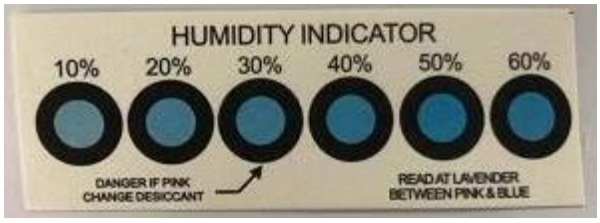


Figure 5-4 Normal Humidity Indication

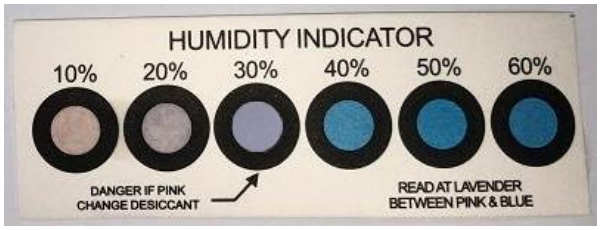


Figure 5-5 Abnormal Humidity Indication

The shelf life of the UM981S module packaged in vacuum-sealed aluminum foil antistatic bags is one year.

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