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INSTALLATION AND OPERATION

USER MANUAL

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UM621 Series

Multi-GNSS Dual-frequency

Integrated Positioning Module

Revision History

Version	Revision History	Date
R1.0	First release	Oct. 2022
R1.1	Add notes on the VCC_RF pin; Add Chapter 3.6 Power Supply Requirements	Apr. 2023
R2.0	Add the industrial grade module; Update related parameters; Add section 2.2.2 Installation of the Module	Sept. 2023
R2.1	Add UM621A-32, supporting wake-on-motion; Update the TTFF and velocity accuracy; Modify the voltage range of V_BCKP	Feb. 2024

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Foreword

This document describes the information of the hardware, installation, specification and the use of Unicore UM621 series modules.

Document Structure

1. Product introduction
2. Installation guide
3. Technical specifications
4. Package
5. Clean
6. Reflow soldering

Contents

1 Introduction

1.1 Overview

UM621 series modules are GNSS dual-frequency modules with MEMS integrated navigation independently developed by Unicore Communications, Inc. Based on the multi-system, dual-frequency and high-performance GNSS SoC – UFirebird II (UC6580), and with the built-in six-axis inertial measurement unit, the modules support multi-system dual-frequency joint positioning and single system standalone positioning, and can output GNSS+MEMS integrated positioning results continuously even in tunnels and underground garages.

The manufacturing process of the UM621 series modules is in line with IATF 16949, and the GNSS chip inside the automotive grade module conforms to the requirements of AEC-Q100.

Figure 1-1 UM621 Series Modules (Left: Automotive; Right: Industrial)

Main Model	Sub-model	Operating Temperature		Grade		System						Interface				Wake on Motion (WOM)	Data Update Rate
		-40°C~+85°C	-40°C~+105°C	Professional	Automotive	GPS	BDS	GLONASS	Galileo	QZSS	SBAS	UART1	UART2	I²C*	SPI*		
UM621A	02	●			●	●	●	●	●	●	●	●	●	●	●		1Hz/ 5Hz*/ 10Hz*
UM621A	32	●			●	●	●	●	●	●	●	●	●	●	●	●	1Hz/ 5Hz*/ 10Hz*
UM621	02	●		●		●	●	●	●	●	●	●	●	●	●		1Hz/ 5Hz*/ 10Hz*

* The default data update rate is 1Hz; specific firmware supports 5 Hz and 10 Hz.

1.2 Key Specifications

Power	
Voltage	+2.7 V~3.6 V DC (non-WOM) +3.0 V~3.6 V DC (WOM)
Power Consumption	330 mW (automotive grade, typical value) 168 mW (industrial grade, typical value)
RF Input	
Constellations	GPS/GLONASS/BDS/Galileo/QZSS
Standing Wave Ratio	≤2.5
Input Impedance	50 Ω
Antenna Gain	15 dB ~ 30 dB
Physical Characteristics	
Dimensions	16.0 mm∗12.2 mm∗2.4 mm
Environmental Specifications	
Vibration	UM621A: GB/T 28046.3, ISO 16750.3 UM621: GB/T 2423.43, IEC 60068-6
Shock	UM621A: GB/T 28046.3, ISO 16750.3 UM621: GB/T 2423.43, IEC 60068-5
Input/ Output Data Interface	
UART x 2	LVTTL level Supported baud rate: 115200 ~ 460800 bps
* I^{2}C x 1	Address: 7 bit Operating in slave mode Transfer rate: 400 Kbps
*SPI x 1	Alternate function of pin 18~21 Operating in slave mode Maximum transfer rate: 4 Mbps
GNSS Performance	
Frequencies	GPS L1 C/A, L5 GLONASS G1 BDS B1I, B1C*, B2a

	Galileo E1, E5a QZSS L1, L5 SBAS	
Time to First Fix (TTFF)	Cold Start	26s
	Hot Start	2s
	Reacquisition	2s
Horizontal Positioning Accuracy	1.5 m CEP (dual-frequency quad-constellation, open sky)	
Velocity Accuracy (RMS)[1]	0.05 m/s	
INS Positioning Error	< 2% of distance traveled without GNSS	
Sensitivity	GNSS	
	Tracking	-162 dBm
	Cold Start	-148 dBm
	Hot Start	-158 dBm
	Reacquisition	-160 dBm
GNSS Data Update Rate	1 Hz / 5 Hz* / 10 Hz*	
INS Data Update Rate	10 Hz / 20 Hz* / 50 Hz*	
INS Raw Observation Output Rate	50 Hz / 100 Hz	
1PPS Accuracy (RMS)	20 ns	
Data Format	NMEA 0183, Unicore Protocol	

* Items marked with an asterisk are supported by specific firmware.

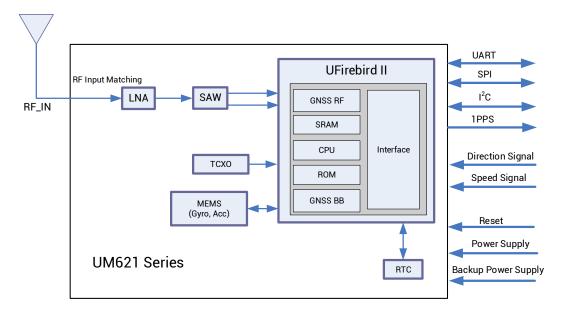[1] 68% at 30 m/s for dynamic operation, open sky

1.3 Interfaces

Figure 1-2 UM621 Series Modules Block Diagram

UART

UART1 is the main serial port of UM621 series modules, supporting data transmission and firmware upgrade, and the signal input/output voltage level is LVTTL. The baud rate can be configured by users[2], and the maximum is 460800bps. Ensure that UART1 is connected to a PC or an external processor for firmware upgrade.

UART2 only supports data transmission and can't be used for firmware upgrade.

MEMS

UM621 series modules integrate a six-axis MEMS, including a three-axis gyro and a three-axis accelerator. MEMS provides information on carrier attitude and speed changes, combined with GNSS data to output integrated positioning and navigation solution. The combination of GNSS+MEMS ensures better positioning performance than standalone GNSS, providing continuous and uninterrupted positioning, especially in the conditions with poor signals, such as tunnels, underground garages and urban canyons.

1PPS

UM621 series modules output 1PPS with adjustable pulse width and polarity.

1PPS is not for timing application.

nRESET

Active LOW, and the active time should be no less than 10 ms.

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[2] For more information, see *Unicore FirebirdII Protocol Specification.*

2 Product Installation

2.1 Preparations

UM621 series modules are Electrostatic Sensitive Devices (ESD) and must be installed with special precautions when handling. Please take the following protective measures before opening the anti-static plastic box.

- Follow the steps in section 2.2 in correct order.
- Electrostatic discharge (ESD) may cause damage to the device. All operations mentioned in this chapter should be performed on an antistatic workbench, using an antistatic wristband and a conductive foam pad. If the antistatic workbench is unavailable, wear an antistatic wristband and connect the other end to a metal frame to play a role in antistatic protection.
- Hold the edge of the module, and DO NOT touch any components of the module.
- Please check carefully whether the module is obviously loose or damaged. If there are any problems, please contact Unicore or the local dealer.

Figure 2-1 shows the typical installation of UM621 series evaluation kit (EVK).
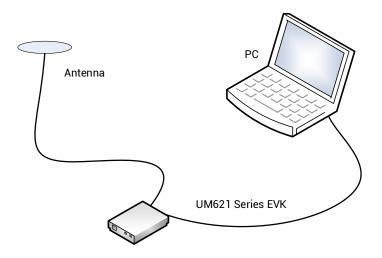

Figure 2-1 Typical Installation of UM621 Series EVK

Please prepare the following items before installing the UM621 series modules.

- UM621 series EVK (with AC Adapter)
- UM621 series modules *User Manual*
- Unicore UPrecise software package
- Accessory GNSS antenna
- USB cable and straight through serial cable

● PC or Laptop with serial ports (Windows 7 and above)

☞ Please keep the packing box and anti-static plastic box for storage and handling.

2.2 Hardware Installation

2.2.1 Installation of EVK

After the above preparations, please follow the steps below to install, which is used for satellite navigation test only.

Step 1: Make sure to take full anti-static measures, such as wearing an anti-static wristband and grounding the workbench.

Step 2: Open the UM621 series evaluation kit and take out the evaluation board.

Step 3: Use the GNSS antenna with appropriate gain and fix it in a non-blocking area; use the appropriate cable to connect the antenna with UM621 series evaluation board.

Step 4: Connect a PC to the EVK serial port through the USB cable or straight through serial cable.

Step 5: Open UPrecise software on the PC.

Step 6: Control the receiver through UPrecise to display constellations view, log messages, and receiver status, etc.

2.2.2 Installation of the Module

UM621 series modules must be rigidly connected to the vehicle body and firmly fixed.

☞ The antenna should be installed with the front facing up as much as possible and firmly fixed; ensure that the elevation angle of the environment where the antenna is located is greater than 15° and the space is unobstructed.

☞ Ensure that there is no strong interference source within the frequency of 1568 ± 20 MHz in the environment where the antenna is located.

2.2.2.1 Installation Instructions

The UM621 series modules must be firmly connected to the vehicle to prevent any offsets or vibrations between the module and the vehicle. UM621 series modules should not be installed in the suspension part of the vehicle (elastic part). When the vehicle is moving, any change of position relative to the vehicle coordinate system will seriously affect the UM621 series modules and prevent them from working normally.

2.2.2.2 Installation Angle

The vehicle coordinate system is XYZ, and the module coordinate system is xyz, as shown in Figure 2-2 and Figure 2-3. The module's installation angle angleX, angleY and angleZ are defined as below:

1. Align the initial state of xyz coordinate system with that of XYZ coordinate system
2. Rotate γ angle of the module around the z axis
3. Rotate α angle of the module around the new x axis
4. Rotate β angle of the module around the new y axis
5. The module is now in the same state as the actual installation, with that, angleX=α, angleY=β, angleZ=γ
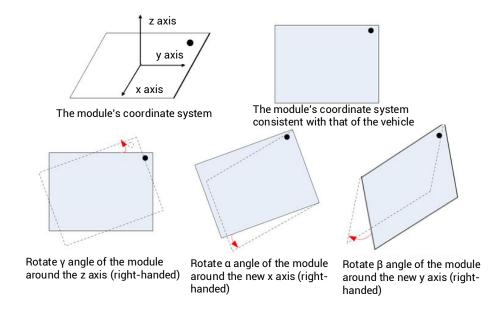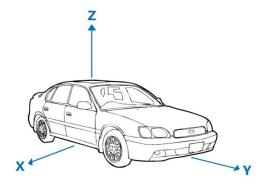

Figure 2-2 Coordinate System of the Module

Figure 2-3 Coordinate System of the Vehicle

☞ The coordinate system of the module must be consistent with that of the vehicle, which means: x-axis and X-axis are parallel in the same direction, y-axis and Y-axis are parallel in the same direction, and z-axis and Z-axis are parallel in the same direction.

2.2.2.3 Installation Mode

● **Free Installation (Default Mode)**

UM621 series modules integrate a three-axis gyroscope and a three-axis accelerometer, with the built-in self-calibration algorithm, which supports the free installation of the module with respect to any installation angle of the vehicle coordinate system, such as, the completely horizontal installation, inclined installation at a certain angle, and flip installation.

● **Fixed Installation**

According to the definition of installation angle, the accurate installation angle is manually configured into the module. This installation method takes a shorter calibration time. When configuring the installation angle manually, the maximum error is limited to ±5 degrees.

2.2.2.4 Reference Messages

1. CFGROTAT

Message format: $CFGROTAT,angleX,angleY,angleZ,mode

Description: Set or output the installation angle of the module with respect to the vehicle coordinate system.

Parameters:

◆ angleX, angleY and angleZ are defined in section 2.2.2.2, with the unit of 0.01°

◆ mode stands for the installation mode:

0 – General installation mode, the input value of the installation angle is relatively coarse (within 10 degrees)

2 – Automatic installation mode, no need to input the installation angle, only calibration is required.

Notes:

1) Choose 0 for fixed installation mode and 2 for free installation mode;

2) Input the actual installation angles including angleX, angleY, and angleZ into the module. After the configuration is completed, save the configuration to the flash using the CFGSAVE command, otherwise it needs to be identified again at the next boot.

3) Any configuration on the INS will cause the module to be re-initialized during normal operation or after power-off and restart, and the previously completed or ongoing calibration operations will be reset.

2. SNRSTAT

Message format: $SNRSTAT,insstatus,odostatus,InstallState,Mapstat

Description: Output initial status (applicable for both fixed installation mode and free installation mode)

Parameters:

◆ insstatus: Initialization status of INS

-1: IMU device failure

0: Disabled

1: Initialization starts

2: The installation angle is known

3: Initialization is completed

◆ odostatus: Odometer initialization status

-1: Odometer device failure

0: Disabled

1: Initialize the scale factor

2: The scale factor initialization is completed

3: The scale factor calibration is completed

◆ InstallState:

-1: IMU device failure, unable to estimate the installation angle

0: Calibration in progress

1: The current quality of satellite information is insufficient and better satellite conditions are required

2: The current vehicle motion is insufficient and acceleration is required

3: The current speed of the vehicle is too low and it's required to be increased.

◆ Mapstat:

-1: No serial port is configured to enter MAP information

-2: The MAP information is abnormal

0: No MAP message is received by the serial port or the MAP message is timeout

1: MAP information is received but not applied to the integrated navigation

2: MAP information is received and applied to the integrated navigation

Fully Free Installation Test

1) Install the module completely freely

2) Input the command $CFGROTAT,0,0,0,2 (no configuration is required for the factory mode)

3) Input the command $CFGSAVE (no configuration is required for the factory mode)

4) The process of self-calibration should satisfy above conditions of parking, satellite quality, vehicle motion, etc. Confirm whether the self-calibration is completed using the $SNRSTAT command, and when the insstatus becomes 3, the self-calibration is completed.

5) Make sure the self-calibration is completed before entering the road with poor satellite quality.

6) If hot start is needed in underground garages, please continuously power the V_BCKP.

3. CFGACC

Message format: $CFGACC,accthreshold,modeenable

Description: Set or output the wake-on-motion configuration

Parameters:

◆ accthreshold: Configure the accelerometer threshold under the mode of wake-on-motion, unit: mg, range: 0~1500

◆ modeenable:

0: Disable

1: Enable

2.2.2.5 Module Calibration and Notes

● **Self-Calibration**

After the installation of the UM621 series modules, the self-calibration is required to ensure the accuracy of the module output. In the process of the self-calibration, the module estimates installation status parameters and sensor parameters. The module is in GNSS navigation mode before the self-calibration is completed, and is in GNSS + INS integrated navigation mode after the self-calibration is completed.

● **Conditions of Completing Self-Calibration**

– The self-calibration is triggered after power on, it's required to stop the car for more than three minutes;

– Good satellite visibility is required during the process of the self-calibration (the number of visible satellites is not less than six, and CN0 is above 30 dB), the better the satellite observation quality is, the faster the calibration will be.

– It's required to make 90-degree turns for more than five times while the vehicle is running normally (this step is unnecessary for fixed installation mode).

– Keep the forward driving speed above 36 km/h on the premise of normal driving. The more times of acceleration (it's recommended to drive at the acceleration

greater than 0.5 m/s^2 for no less than 10 times) and the longer the driving time is, the faster the calibration will be.

After the first alignment of inertial navigation (insstatus 3), it is still necessary to drive for about 15 minutes in the normal open environment to train the inertial navigation device adequately. Otherwise the navigation accuracy may be slightly worse if the vehicle enters a complex environment such as a tunnel and garage immediately after the first alignment.

Notes:

1) The normal use of the module only requires one self-calibration process.
2) After the INS module is calibrated, it can be moved only after the power is completely cut off, including the main power VCC and the backup power V_BCKP.
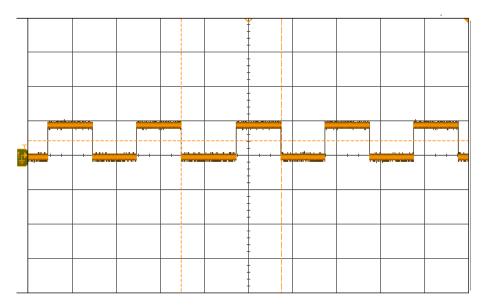
2.2.2.6 Wake-on-Motion

The wake-on-motion function is realized by means of the on-board IMU.

Send the CFGACC command to enable the wake-on-motion and set the corresponding threshold value.

When the IMU detects the acceleration value exceeding the threshold value, pulse signals will be output from Pin17 of the GNSS module.
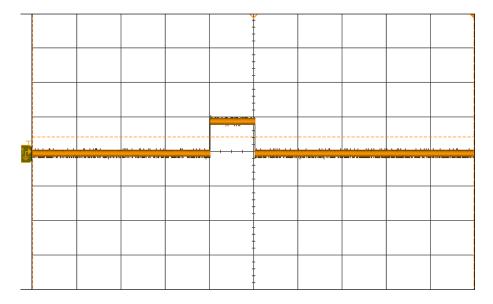
IMU cannot participate in GNSS+INS integrated navigation after entering the wake-on-motion mode, so it is recommended to keep the wake-on-motion disabled until you are going to turn off the engine and park the car.

The module outputs pulse signals of 2Hz with 50% duty cycle when the car is in continuous motion, as shown below.

For a single motion, the duty cycle is shown as below.

3 Technical Specifications

3.1 Electrical Specifications

Absolute Maximum Ratings

Item	Min.	Typ.	Max.	Unit	Description
Power Supply (VCC)	-0.5		3.6	V	Main power supply
Backup Voltage (V_BCKP)	-0.5		3.6	V	Backup power supply for RTC
RTC Time Keeping		65		µA	Including the standby current for the sensor to wake up the host
		5		µA	
Digital IO Voltage	-0.5		3.6	V	Voltage of the digital signal pins
Antenna Input Power (RF_IN)	-		+3	dBm	Maximum input power of antenna

3.2 Operational Conditions

Item	Symbol	Min.	Typ.	Max.	Unit	Condition
Power Supply	VCC	2.7	3.3	3.6	V	Non-WOM
		3.0	3.3	3.6	V	WOM
Ripple Voltage	$V_{p\text{-}p}$			50	mV	
Peak Current	I_{ccp}			134	mA	VCC=3.0 V
Tracking Average Current (Automotive)	I_{ACQ}	95	110	122	mA	VCC=3.0 V
Tracking Average Current (Industrial)	I_{ACQ}	46	56	62	mA	VCC=3.0V
Low Level Input Voltage	V_{IL}	0		0.2*VCC	V	
High Level Input Voltage	V_{IH}	0.7*VCC		VCC + 0.2	V	
Low Level Output Voltage	V_{OL}	0		0.4	V	I_{out}=-2 mA
High Level Output Voltage	V_{OH}	VCC−0.4		VCC	V	I_{out}=2 mA
Antenna Gain	G_{ANT}	15	20	30	dB	

3.3 Dimensions

The dimensions of UM621 series modules are as follows:

Parameter	Min (mm)	Typical (mm)	Max (mm)
A	15.9	16.0	16.5
B	12.05	12.2	12.35
C	2.2	2.4	2.6
D	0.9	1.0	1.3
E	1.0	1.1	1.2
F	2.9	3.0	3.1
G	0.9	1.0	1.3
H	0.7	0.8	0.9
K (Outer edge of the stamp hole)	0.7	0.8	0.9
N (Inner edge of the stamp hole)	0.4	0.5	0.6
M	0.8	0.9	1.0

Figure 3-1 Mechanical Layout

Technical Specifications

3.4 Pin Definition

Figure 3-2 Pin Assignment

Pin No	Name	I/O	Electrical Level	Description
1	nRESET	I	LVTTL	Reset pin, active low. Keep it floating if not in use.
2	DEL	I	—	Interface selection pin. If DEL is set low level, SPI is available. If DEL is set high or floating, UART and I^2C become available.
3	TIMEPULSE	O	LVTTL	Pulse per second (1PPS)
4	WHEELTICK	I	LVTTL	Odometer speed pulse input. Keep it floating if not in use. It is strongly recommended to use this pin. The maximum pulse frequency is 5K Hz, and the minimum pulse width is greater than 100 μs. Note: Incorrect signals of the odometer will lead to serious problems in the use of the product. Please make sure the signal is correct.
5	RXD2	I	LVTTL	UART 2 receiving data
6	TXD2	O	LVTTL	UART 2 transmitting data
7	NC	—	—	Floating
8	nRESET	I	LVTTL	Reset pin, active low. Keep it floating if not in use.

Pin No	Name	I/O	Electrical Level	Description
9	VCC_RF	O		Antenna feed output. It is recommended to use an external power supply rather than the VCC_RF pin to feed the antenna.[3]
10	GND	—	—	Ground
11	RF_IN	I	—	GNSS signal input
12	GND	—	—	Ground
13	GND	—	—	Ground
14	LNA_EN	O	—	Enable external LNA; high level by default
15	FWD	I	LVTTL	Odometer direction input. Keep it floating if not in use. It is strongly recommended to use it. High level = forward Low level = reverse Note: Incorrect signals of the odometer will lead to serious problems in the use of the product. Please make sure the signal is correct.
16	NC	—	—	Floating
17	WOM / NC	—	—	For the module that supports wake-on-motion, pulse signals will be output from this pin when the IMU detects acceleration higher than the threshold value. For the module that does not support WOM, this pin can be left floating.
18*	SDA / SPI CS_N	—	—	I^2C data (D_SEL=VCC or floating)/SPI chip select (D_SEL=GND)
19*	SCL / SPI CLK	—	—	I^2C clock (D_SEL=VCC or floating)/SPI clock (D_SEL=GND)
20	TXD1/ SPI MISO*	O	LVTTL	SPI Master In Slave Out (D_SEL=GND); UART TXD signal (D_SEL=VCC or floating)
21	RXD1/ SPI MOSI*	I	LVTTL	SPI Master Out Slave In (D_SEL=GND); UART RXD signal (D_SEL=VCC or floating)

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[3] If the antenna power supply 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's recommended to design an independent power rail for the antenna to reduce the possibility of damage to the module.

Pin No	Name	I/O	Electrical Level	Description
22	V_BCKP	I	Non-WOM: 2.0 V~3.6 V; WOM: 3.0V ~ 3.6V	Backup voltage supply, applicable for hot start. If you do not use hot start, connect V_BCKP to VCC. Do NOT leave it floating or connect it to ground. For more requirements on V_BCKP, see section 3.6.
23	VCC	—	Non-WOM: 2.7 V~3.6 V; WOM: 3.0V ~ 3.6V	Supply voltage
24	GND	—	—	Ground

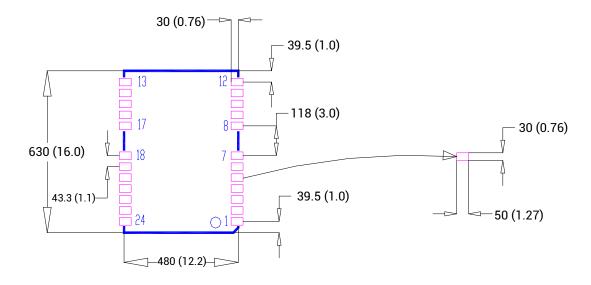* I2C and SPI are supported by specific firmware.

3.5 PCB Packaging

Figure 3-3 UM621 Series Modules Recommended PCB Packaging (unit: mil, in brackets: mm)

☞　When designing PCB solder mask, make sure that the area under the UM621 series module is completely coated with solder mask.

3.6 Power Supply Requirements

Main Supply (VCC)

➤ For the module that does not support wake-on-motion, the voltage range of VCC is 2.7 V ~ 3.6 V.

➤ For the module that supports wake-on-motion, the voltage range of VCC is 3.0 V ~ 3.6 V.

Notes:

● 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 ~ 10 ms.

● Power-on time interval: The time interval between the power-off (VCC < 0.4 V) to the next power-on is recommended to be larger than 500 ms.

Backup Supply (V_BCKP)

When using hot start, users should supply backup power to the module.

➤ For the module that does not support wake-on-motion, the voltage range of V_BCKP is 2.0 V ~ 3.6 V.

➤ For the module that supports wake-on-motion, the voltage range of V_BCKP is 3.0V ~ 3.6 V. Meanwhile, ensure that the voltage at V_BCKP is lower than that at VCC.
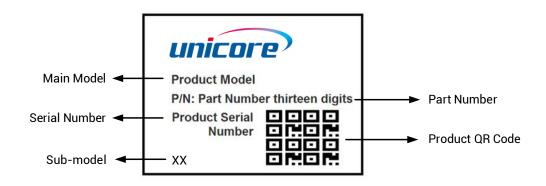
Notes:

● 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 μs ~ 10 ms.

● Power-on time interval: The time interval between the power-off (V_BCKP < 0.4 V) to the next power-on is recommended to be larger than 500 ms.

● The V_BCKP pin cannot be floating or connected to ground. When V_BCKP is not used, it should be connected to VCC or connected to backup power.

4 Package

4.1 Label Description

4.2 Ordering Information

Main Model	Sub-model	Description
UM621A	02	Automotive grade dual-frequency GNSS+MEMS module, operating temperature: -40°C ~+85°C, supporting firmware upgrade, 16.0 mm x 12.2 mm, 500 pieces/reel
UM621A	32	Automotive grade dual-frequency GNSS+MEMS module, operating temperature: -40°C ~+85°C, supporting firmware upgrade and wake-on-motion, 16.0 mm x 12.2 mm, 500 pieces/reel
UM621	02	Industrial grade dual-frequency GNSS+MEMS module, operating temperature: -40°C ~+85°C, supporting firmware upgrade, 16.0 mm x 12.2 mm, 500 pieces/reel

4.3 Package Description

The UM621 series modules use carrier tape and reel (suitable for mainstream surface mount devices), packaged in vacuum-sealed aluminum foil antistatic bags, with desiccant inside to prevent moisture. When using reflow soldering process to solder the 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 degrees Celsius, modules shall be removed from the package during baking.

Figure 4-1 UM621 Series Modules Package

Item	Description
Number of Modules	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

UM621 series modules are rated at MSL level 3. Please refer to the relevant IPC/JEDEC standards for baking requirements. Users may access to the website www.jedec.org to get more information.

The shelf life of UM621 series modules packaged in vacuum-sealed aluminum foil antistatic bags is one year.

5 Clean

DO NOT use alcohol or other organic solvents to clean, which may lead to soldering flux residues flooding into the shielding shell, causing mildew and other problems.

6 Reflow Soldering

In order to avoid the device falling off, the module should be placed on the top of the main board during soldering. Reflow soldering temperature curve is recommended as shown in figure 6-1 below (M705-GRN360 is recommended for solder paste).

Note: The module can be soldered only once.

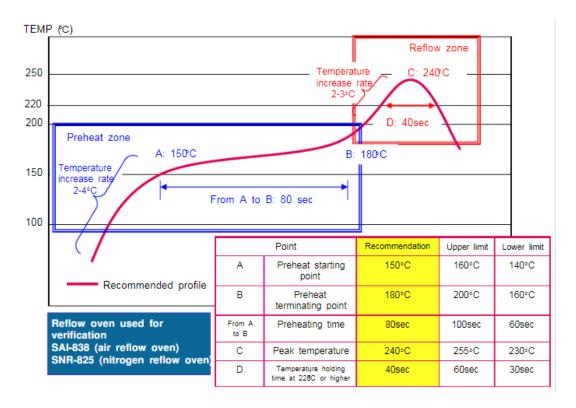|	Point	Recommendation	Upper limit	Lower limit
A	Preheat starting point	150°C	160°C	140°C
B	Preheat terminating point	180°C	200°C	160°C
From A to B	Preheating time	80sec	100sec	60sec
C	Peak temperature	240°C	255°C	230°C
D	Temperature holding time at 228C or higher	40sec	60sec	30sec

Figure 6-1 Reflow Soldering Temperature Curve

Note: The apertures in the stencil need to meet the customer's own design requirements and inspection specifications, and the thickness of the stencil should be above 0.15 mm. It is recommended to be 0.18 mm.

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