目录

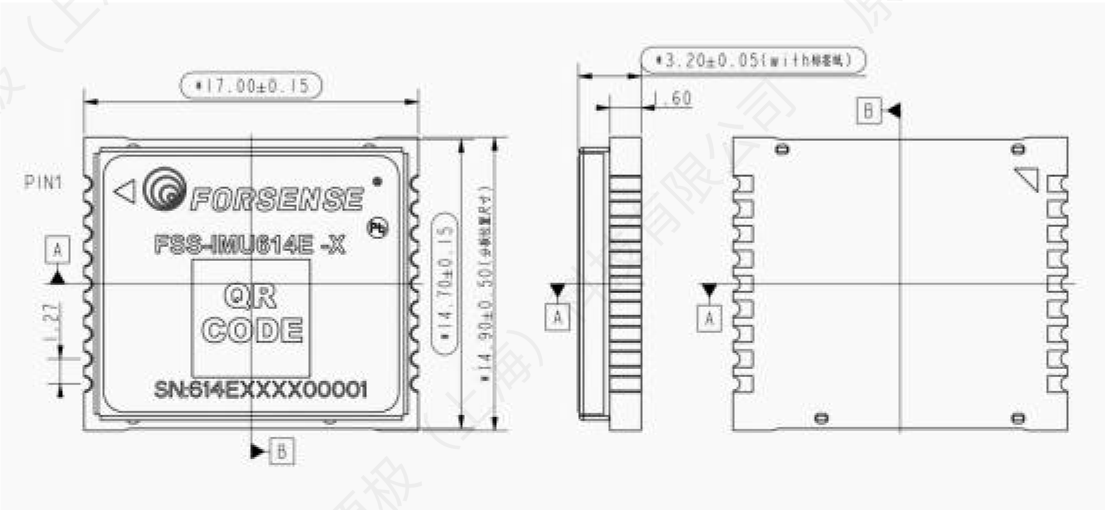
1. Overview

The IMU614E-P inertial module enables low-cost, high-precision, anti-magnetic interference attitude measurement and orientation through IMU and GNSS data fusion algorithms. Especially in the field of RTK tilt mapping, accurate and consistent tilt position correction can be achieved.

For the surveying and mapping pole, the measuring accuracy of ±2.5cm is provided in the range of 0-30 ° inclination Angle, and the installation deviation Angle correction function can be adapted to all kinds of centering rods.

2. Shape structure

Figure 1 Outline structure and dimensions (unit: mm)



3. Electrical characteristics

3.1 Maximum tolerance value

Table 1 Maximum absolute rated value

Parameters	Symbols	Radius	Units
Supply voltage	VCC	-0.3 to 4	V
Power source	GND	–	–
Input pin voltage	V in	-0.3 to VCC+0.2	V
Use temperature	Tot	-40 to 85	℃
Storage temperature	Tstg	-40 to 85	℃

3.2 Working Conditions

Table 2 Working conditions

Parameters	Symbols	Minimum value	Typical value	Maximum value	Units
Supply voltage	VCC	3.0	3.3	3.6	V
VCC maximum ripple	Vrpp		+ 40		mV
Power Consumption	P		0.07		W
Use temperature	T	-40		85	℃
Storage temperature	T	-40		85	℃

3.3 I/O Threshold Characteristics

Table 3 I/O Threshold Characteristics

Parameters	Symbols	Minimum value	Typical value	Maximum value	unit
Input pin low	V in_ low	0		VCC * 0.2	V
Input pin high	V in_high	VCC * 0.7		VCC + 0.2	V
Output pin low	Vout_ low	0		0.45	V
Output pin high	Vout_high	VCC - 0.45		VCC	V

		Mode	Features	Description
11	CAN TX / TX4 / I2C_SDA	1	CAN_TX	CAN send pins; Read data from the CAN controller to the bus driver
		2	TX4	Receive asynchronous data output
		3	I2C_SDA	I2C serial data
12	RX3	Receive asynchronous data input		
13	SPI_MOSI	SPI serial data input		
14	SPI_MISO	SPI serial data output		
15	SPI_CLK	SPI serial clock		
16	SPI_CS	SPI slice selection		
17	PPS	External synchronous sampling trigger signal; (Access RTK second pulse pin)		
18	TX3/DRDY	Receive asynchronous Data output/available for Data Ready		

Note 1: The IMU hardware needs to be reset once using /RST during host initialization

For information about the hardware design of the module, see the document FSS-IMU614E-XX Hardware Design Manual.

4. Minimum recommended circuit

Figure 3 Connection diagram

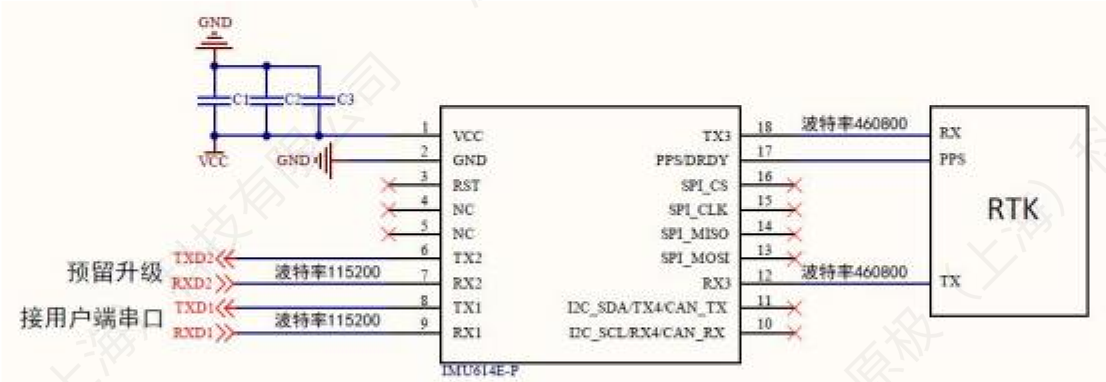


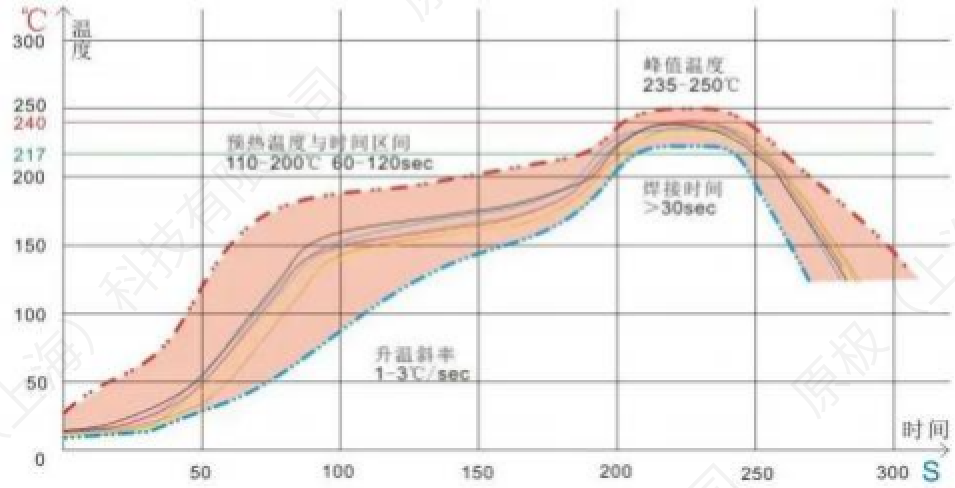
Table 5 recommends BOM

No.	MPN	Description	Manufacture	Designator	Qty
1	CL10A106KP8NNNC	MLCC 10uF ±10% 10V X5R 0603	SAMSUNG	C1	1
2	CC0402KRX7R9BB104	MLCC 100nF ±10% 50V X7R 0402	YAGEO	C2	1
3	CL05C101JB5NNNC	MLCC 100pF ±5% 50V C0G 0402	SAMSUNG	C3	1

For module-related hardware design information, see the document FSS-IMU614E-XX Hardware Design Manual.

5. Recommend welding furnace temperature curves

Figure 4 Welding furnace temperature curve



item	Minimum Boundaries	Maximum limit	Units
Maximum temperature rise slope (target =0.8) (time distance to calculate slope =60 seconds)	1	3	Degrees per second
Maximum temperature drop slope (distance in time to calculate slope =60 seconds)	-3	-1	Degrees per second
Preheat temperature and time interval	60	120	seconds
Reflux time (period over 217 ° C)	40	70	seconds
Maximum temperature	235	250	Degrees Celsius
Maximum number of reflow		1	time

For more SMT information about modules, see the Primary -LCC Module_SMT Application Guide.

Note:

1. Module welding reflow, it is recommended to use eight temperature zone and above reflow welding equipment;
2. Because the module is a high-precision sensor product, it is more sensitive to any deformation:

If the PCB board thickness is less than 1.0mm, it is recommended to make reflow loading tools to prevent the PCB board from deforming at high temperature, affecting the coplanarity of welding.

- It is recommended that customers choose PCB board with high TG value to avoid the deformation of the board due to high temperature reflux, resulting in warping, extrusion, air welding and poor tinning.

3. Because there are sensitive devices in the module, the maximum temperature of the reflow welding machine used by the customer should not exceed 260℃

(refers to the temperature at the top of the package measured on the surface of the package).

4. It is recommended to use lead-free solder paste, recommended solder paste brand model: Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5

5. Because there are sensitive devices in the module, the performance of the module should be reduced due to the secondary reflux;

6. Cooling:

- Controlled cooling slope to prevent negative welding effects (solder joints become more brittle) and mechanical stress within the product, controlled cooling to help achieve bright welding surface effect, fine crystal particles and low contact Angle, avoid rapid cooling changes caused by the warping of the shield cover.

7. Inspection of appearance:After

- module welding, use X-ray and optical magnifying glass inspection method to check the welding quality, please refer to IPC-A-610F related standards.

8. When using electric soldering iron for welding, the temperature should be controlled at 260℃~290℃, and the single welding time should not exceed 3s. And do anti-static treatment;

6. ESD prevention

Static electricity can lead to intermittent or permanent circuit damage, great harm to electronic products, most of the analysis is ESD damage;

Therefore, the module of electrostatic protection is particularly important, the production and transportation process should be strictly in accordance with electrostatic protection operations, must follow the following conditions:

Do not touch the module with bare hands, especially the Pin position.

SMT mounter, working table, soldering iron and other equipment should be grounded.

Workers should wear a human anti-static

wristband with a good grounding cable (cordless electrostatic wristband is not allowed, it is recommended to wear anti-static gloves).

Packaging and PCB must be qualified anti-static materials.

7. The RTK configuration requires

baud rate of 460800

PPS second pulse: 1s once, rising edge trigger, pulse width 5ms, aligned to UTC time, high level must not be higher than 5v.

- If the RTK board supports the Novate binary protocol, you need to configure the RTK board output the following two instructions:

BESTPOSB 10hz

PSRVELB 10hz

Close other statements

Configure instruction for IMU AT+GNSS_CARD=UNICORE\r\n

For Novate binary protocol, the system status bit changes to 21 after successful configuration, and GNSS_CARD=482 for AT+CONFIG command query.

- If the RTK board is NMEA protocol, the following three commands need to be configured:

GPGGA 10hz

GPRMC 10hz

GPGST 10hz

Close other statements

Configure the instruction AT+GNSS_CARD=OEM\r\n for IMU

After the NMEA protocol is configured successfully, the system status bit changes to 22, and the AT+CONFIG command queries GNSS_CARD=0.00000.

8. Output Protocol

Note:

- must access the RTK data shown in Section 8 and successfully send the input protocol in sections 10.1 and 10.4 to output this frame message at the output frequency of 10hz.
- Sum and check is the sum of all bytes in the frame except the check bits.
- Small-endian mode, sending the low bytes first.

Table 6 Output protocol

Contents	**Type**	**Relative position**
Frame header 1:0xAA	uint8	0
Frame header 2:0x55	uint8	1
Frame ID: 0x0166	uint16	2
Frame length: 0x0069	uint16	4
Pole base latitude - degree (positive for north latitude, negative for south latitude)	double	6
Pole base longitude - degree (positive for east longitude, negative for west longitude)	double	14
Bar base elevation - meters	double	22
East distance of rod base relative to control point - m (This item is for research and test use only)	float	30
The north distance of the bottom of the rod relative to the control point - meters (This is for research and test use only)	float	34
Celestial distance of rod base relative to control point - meters (This is for research and testing only)	float	38
Dip-degree	float	42
Precision factor	float	46
Gyro x, y, Z-axis deg/s Accelerometer x, y, Z-axis g	float*6	50
Milliseconds in UTC days (board output NMEA)/ Milliseconds in GPS week (board output Novate binary)	uint32	74
System status	uint32	78
Current rod length -mm	uint16	82
Calibrate progress	float	84

RTK fixed solution state (same as positioning state in GGA) 0: unpositioned 1: single point positioning 2: pseudo-distance differential positioning 4: fixed solution 5: floating point solution	uint8	88
RTK star count	uint8	89
RTK differential delay	uint8	90
Reserved	int16*2	91
Azimuth	float	95
Roll Angle	float	99
Pitch Angle	float	103
Heading Angle	float	107
Add and check	uint32	111

Table 7 System State Meaning Correspondence table

System Status	State meaning
1	Respond to initialization instructions
3	Respond to rod length configuration instructions
5	Respond to rod arm configuration instructions
6	Respond to calibration instruction
9	Respond to save parameterinstruction
20	Respond to the rotation Angle configuration instruction
21	Respond to GNSS protocol configuration as Novate protocol
22	The response GNSS protocol is configured as NMEA protocol

Note 1: Accuracy factor less than 1.0 indicates that the tilt measurement accuracy is good, if 99.99 indicates that there is no initialization or abnormal state (such as IMU overrange,RTK long time out of lock, etc.), need to initialize the operation.

Note 2: If the calibration progress is -99 before the installation deviation calibration is started, it means that the module has not been calibrated for the installation deviation of the center rod.

Note 3: If RTK is positioned and PPS output is normal, the fixed solution state should be greater than 0.

9. Sample usage

9.1 First Use

1. Configure the RTK board type:

If the output of the board supports the Novate binary protocol, then configure the RTK board output BESTPOSB,PSRVELB two frames 10hz output, and send the string "AT+GNSS_CARD=UNICORE\r\n" to the IMU module.

If the output of the board is NMEA protocol, then configure the RTK board to output GPGGA,GPRMC,GPGST three frames 10hz output, and send the string "AT+GNSS_CARD=OEM\r\n" to the IMU module.

2. Confirm the IMU installation coordinate system. If the IMU is installed the default way (X facing forward, Y facing right, Z facing down (label facing up)), no configuration is required, if it is not installed the default way, such as the reverse patch installation, the string is sent "AT+IMU_AXIS=106\r\n", refer to the corresponding section of 12.2 Installation Coordinate System Diagram for details

3. Set the rod length. If the rod length is 2.03 meters, send the string "AT+CLUB_VECTOR=0.0,0.0,2.03\r\n".

4. Configure the lever vector, if the lever vector is (0.035, -0.05, -0.1) m, then send the string "AT+LEVER_ARM =0.035, -0.05, -0.1\r\n"

5. SAVE the parameters and send the string "AT+SAVE\r\n" to calibrate the installation deviation Angle as shown in section 8.8.

9.2 General Use

If the surveying and mapping pole has not been replaced or obvious deformation, impact, etc., it is usually not necessary to re-calibrate the installation deviation Angle. Each power-on only needs to be initialized as shown in section 8.7 before normal use.

9.3 Device Installation

The module should be firmly fixed on a rigid plane to avoid being installed in a position with large vibration.

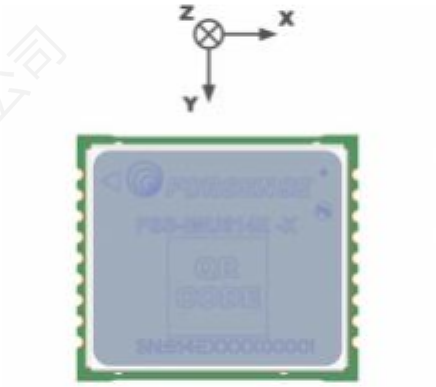
Since there is no coordinate system identification on the module, the installation direction can be confirmed according to the triangle shape symbol on the module. As shown in the figure below, the module follows the front right lower coordinate system, which is defined as follows

X should face forward (pay special attention to the same direction as the laser when cooperating with the laser), Y should face right,

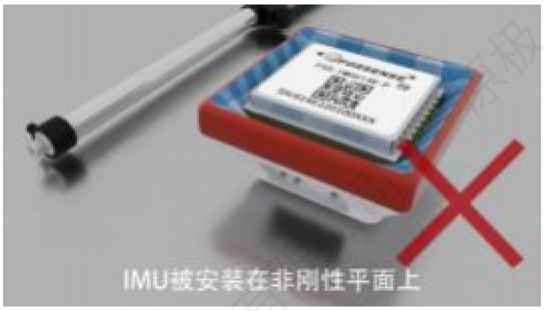
Z facing down (**label facing up**)

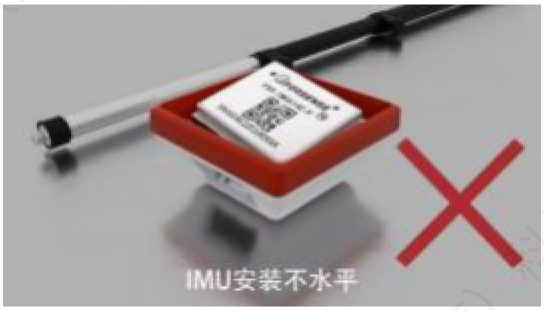
If you cannot install using the default coordinate system, you can adjust the mounting coordinate system using the **10.9** Configuring the Mounting Coordinate System instruction

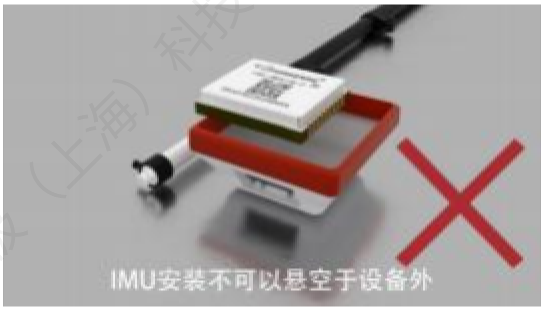
FIG. 9 Installation diagram of the default coordinate system of the module

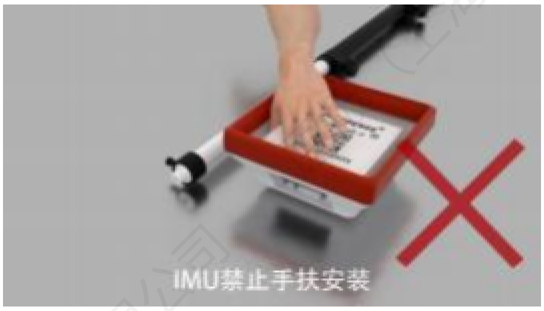


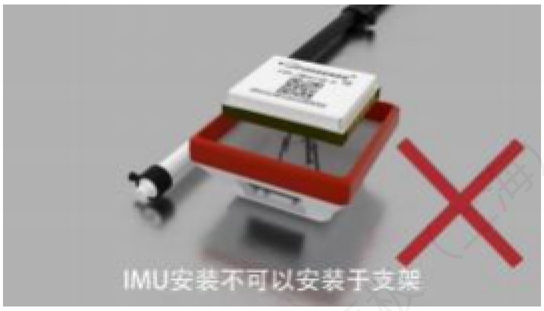
The following installation methods are incorrect installation

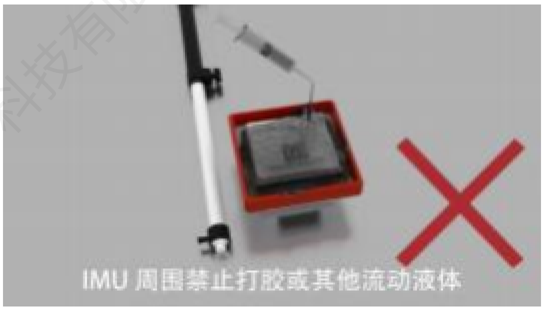








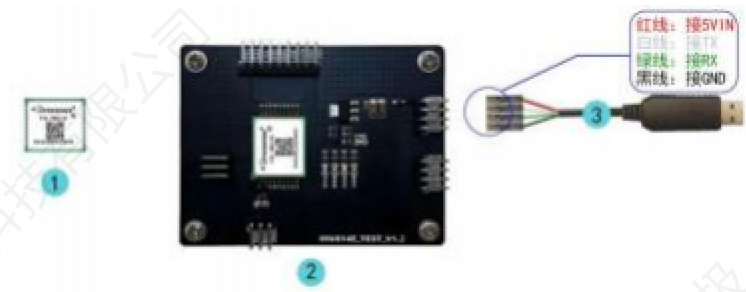




9.4 Example of Connecting the upper Computer

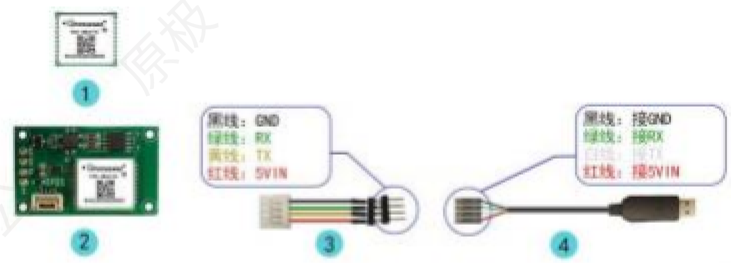
Figure 13 Schematic diagram of module connecting to upper computer

New test baseboard connection diagram



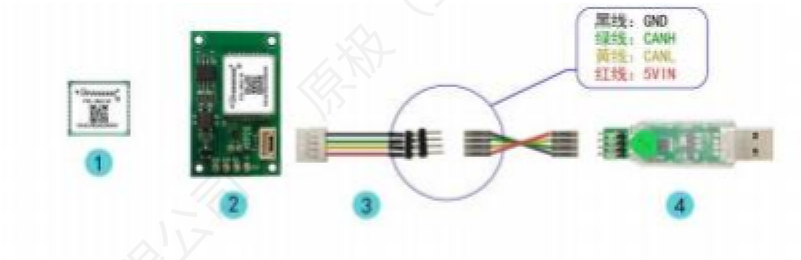
	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	IMU614E新版测试底板	1个
3	TTL串口线	1个

Version 485 Test backboard connection diagram



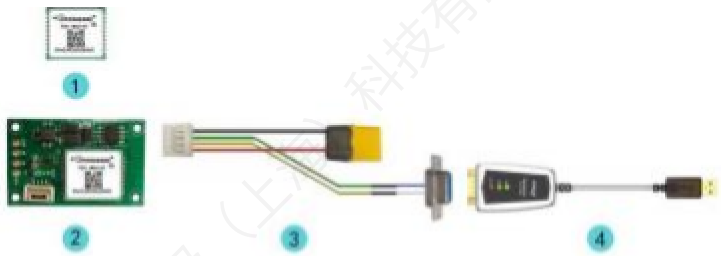
	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	TTL版本测试底板	1个
3	4-PIN接头	1个
4	TTL串口线	1个

CAN version Test baseplate connection schematic



	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	CAN版本测试底板	1个
3	4-PIN接头	1个
4	TTL串口线	1个

The 485 version tests the backboard connection schematic



	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	RS485版本测试底板	1个
3	RS485测试底板测试线束	1个
4	485USB转接线	1个

10. Enter the protocol

Note: Each command must be sent at least 10ms apart

10.1 Configuring the RTK Board Protocol

- If the output protocol of the RTK board is the Novate binary protocol:

  Instruction:AT+GNSS_CARD=UNICORE\r\n

  Answer: OK\r\n

  If this input instruction is received correctly, the system status bit in the output protocol changes to 21.

- If the output protocol of RTK board is NMEA protocol:

  Instruction: AT+GNSS_CARD=OEM\r\n

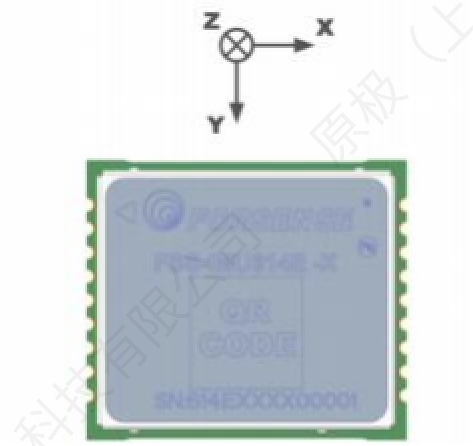
  Answer: OK\r\n

  If this input command is received correctly, the system status bit in the output protocolchanges to 22.

10.2 Configuring arm and lever vectors

The arm bar vector is the three-dimensional vector (X,Y,Z) of the phase center of the RTK antenna relative to the IMU mounting position, in meters. Where,

- If the RTK antenna is positive on the X-axis of the IMU, it is a positive number, otherwise it is a negative number;
- If the RTK antenna is positive on the Y-axis of the IMU, it is positive, otherwise it is negative;
- Positive if the RTK antenna is below the IMU, negative otherwise.



For example configuration arm vector is (0.035, 0.05, 0.1)

command: AT + LEVER_ARM = 0.035, 0.05, 0.1 \ r \ n

response: X = 0.035, Y = 0.05, Z = 0.1 \ r \ n

If this input instruction is received correctly, the system status bit in the output protocol changes to 5.

10.3 Configuring the rod length

Note: The rod length is the distance from the phase center of the antenna to the bottom of the rod for example the configuration rod length is 2.03 meters

Instruction: AT+CLUB_VECTOR=0.0,0.0,2.03\r\n

Answer: LEN=2.03\r\n

If this input instruction is received correctly, the system status bit in the output protocol changes to 3.

10.4 Configuring the Mounting coordinate system

If the installation cannot be performed using the default coordinate system, you need to configure the corresponding coordinate system. Otherwise, data will be abnormal

For example:

Instruction: AT+IMU_AXIS=101\r\n (coordinate system 101~124, 101 is the default coordinate system) Response: IMU_AXIS=101

For the installation diagram corresponding to the coordinate system, refer to Chapter 12 Definition of coordinate system

10.5 Configure the output protocol

Instruction: AT+SETSURVEY\r\n

10.6 Save parameters

Instruction: AT+SAVE\r\n

Answer: OK\r\n

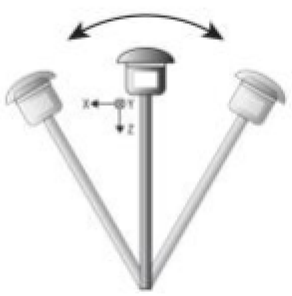
If this input instruction is received correctly, the system status bit in the output protocol changes to 9.

10.7 Tilt measurement initialization

Note: It is not necessary to rock strictly according to the coordinate system, the illustrated coordinate is just a rotation diagram. If the input command is correctly received, the system status bit in the output protocol will become 1

1. After the fixed solution of RTK, send the string "AT+START_ INIT\r\n" and swing the mapping stick back and forth, as shown in Figure 4, for about 5 seconds, until the accuracy factor is less than 0.6.

FIG. 4 Rocking diagram



2 Complete the initialization and begin the tilt measurement.

3. If severe rotation, fall or impact occurs during use, the initialization operation needs to be re-performed.

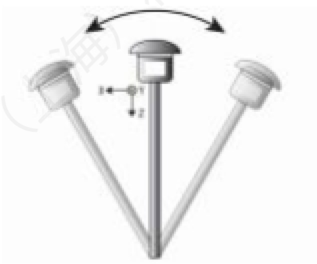
10.8 Enable installation deviation Angle calibration

Attention:

- An installation deviation calibration procedure must be performed after installation of I module.
- Calibration of the installation deviation Angle should be carried out in an open scene.
- Insert the bottom tip of the rod into a hard surface to ensure that the position of the rod bottom does not change during the whole process.
- Since the RTK main engine is generally heavy, the calibration process should be as gentle as possible to prevent the rod deformation from affecting the calibration accuracy.
- It is not necessary to calibrate the installation deviation Angle every time unless the surveying rod is severely impacted, deformed, or re-installed. If this input command is received correctly, the system status bit in the output protocol changes to **6.**

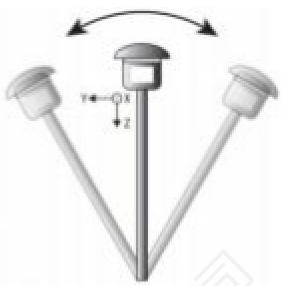
1. It is not necessary to shake the system strictly according to the coordinate system. The illustrated coordinates are only a schematic diagram of the rotation sequence. In an open and unimpeded scene, the string "AT+INST_CALI B=3\r\n" is sent after RTK is fixed. As shown in Figure 5, the mapping stick is swayed back and forth for 10s, left and right, until the calibration progress reaches 25%

FIG. 5 Schematic diagram of rocking

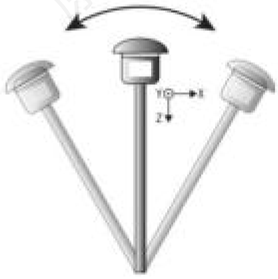


2. Rotate the rod 90 degrees, as shown in FIG. 6, swing the mapping rod back and forth for about 10s. until the calibration progress reaches 50%

FIG. 6 as shown in



3. Continue to rotate the pole 90 degrees, as shown in FIG. 7, rocking the mapping pole back and forth for 10s until the calibration progress reaches 75%, as shown in FIG. 7, rocking diagram



5. Send the string "AT+SAVE\r\n" to save the parameters and complete the calibration.

10.9 Request version number

Instruction: AT+VERSION\r\n

Answer: VERSION =211209\r\n

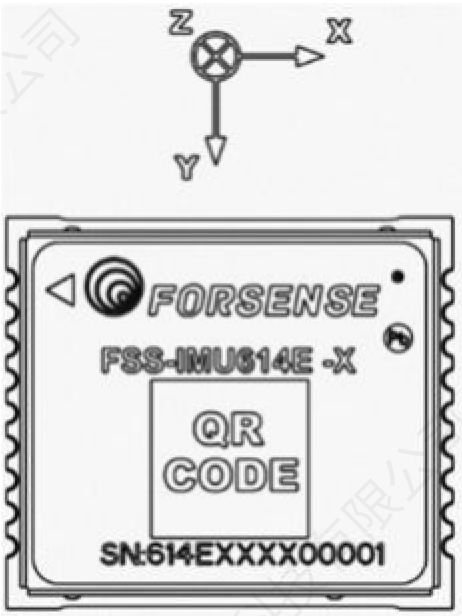
10.10 Querying the Configuration

Query all configured information

instruction: AT+CONFIG\r\n

11. Coordinate System

11.1 Definition of the default coordinate system



The product coordinate system uses the forward-right-down (FRD) coordinate system with X facing forward, Y facing right, and Z facing down (label facing up) Euler Angle ranges as follows:

Rotation around the Z axis: Course Angle Yaw range: -180° ~180°;

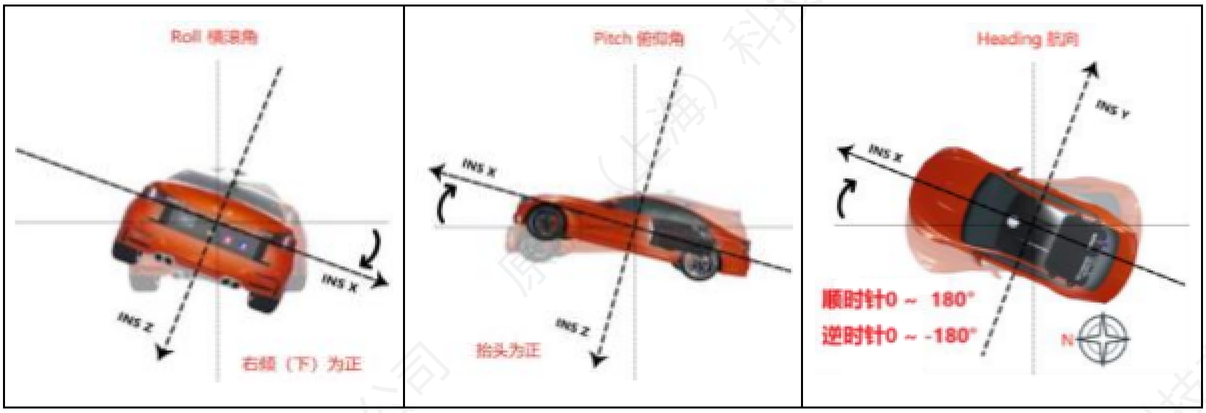
Rotation around the X axis: Roll Angle roll range: -180° ~180°;

Rotation around the Y-axis direction: Pitch Angle range: -90° ~90°.

Note: When used with laser, pay special attention to keep the X direction consistent with the laser direction

For ease of understanding, take the passenger car as an example, roll, pitch, heading Angle diagram is as follows:

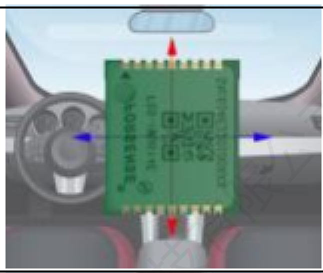
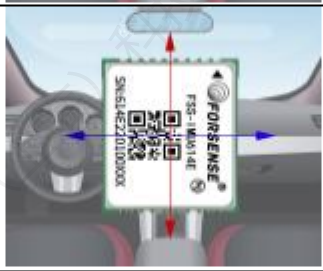
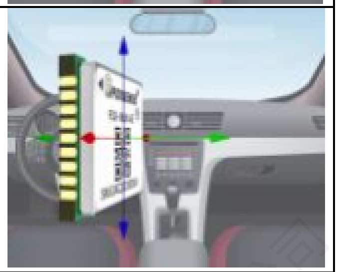
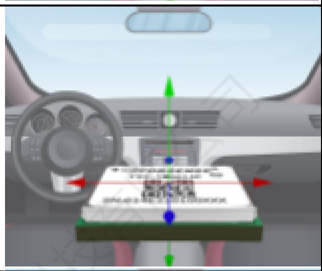
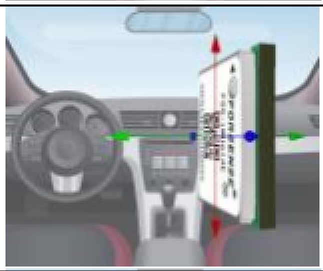
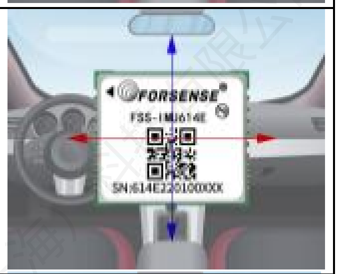
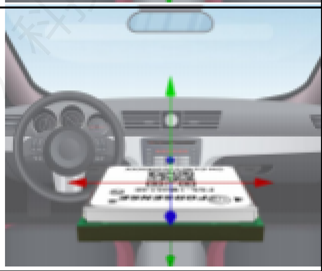
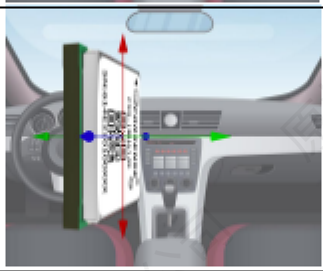
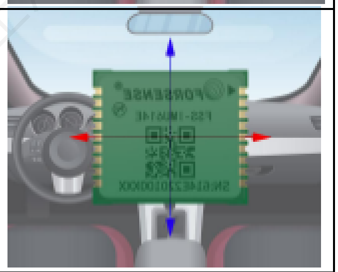
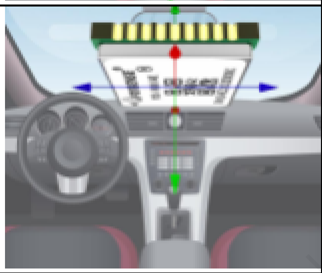
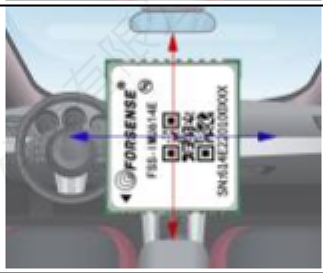
FIG. 21 Schematic diagram of roll, pitch and heading Angle

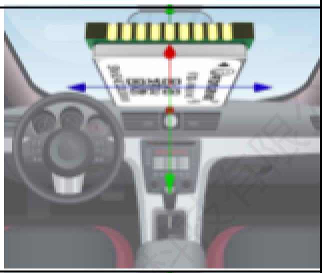
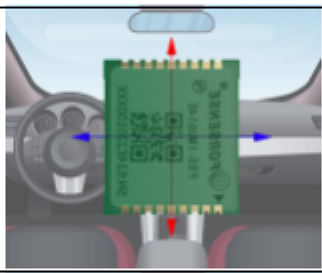
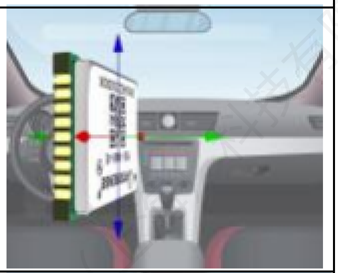
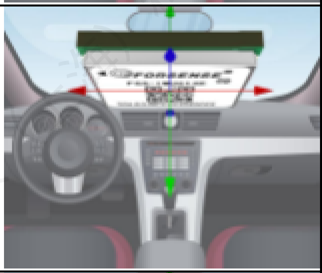
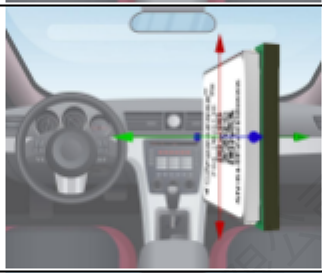
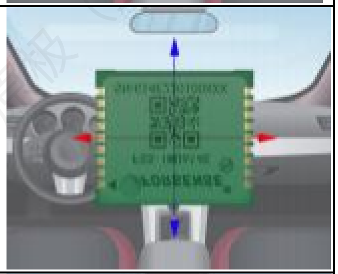
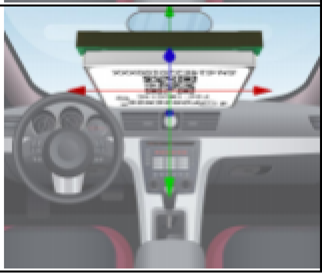
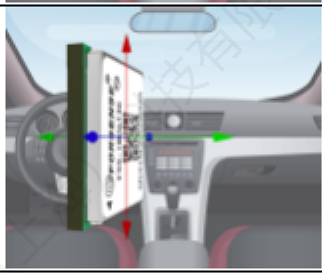
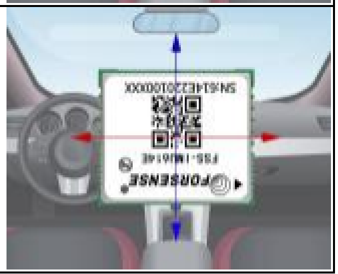


11.2 Instructions for 24 mounting coordinate systems

Schematic illustration: For ease of understanding, the relative position of the IMU module in the internal space of the passenger car is taken as an example. The direction of the front is the front, and the Angle of the lens is the back. The relative position can be confirmed by the direction of the arrow on the module label

Adjusting the installation coordinate system is to adjust the definition of XYZ three axes, so that the XYZ three axes always meet the requirements of X to the front, Y to the right and Z to the down

Coordin	Schematic Diagram	Marking	Schematic Diagram	Sitting	Schematic Diagram
101		109		117	
102		110		118	
103		111		119	
104		112		120	
105		113		121	

Sitting	Schematic Diagram	Sitting	Schematic Diagram	Sitting	Schematic Diagram
106		114		122	
107		115		123	
108		116		124	

12. Packaging

The IMU614E-P module is packaged in a tape seal. Meet efficient production.

12.1 Tape packing

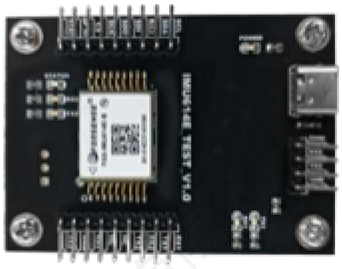
Figure 16 Schematic diagram of reel tape packaging

12.2 Carrier Tape

The following figure shows the position and orientation of the IMU614E-P on the load belt.

Figure 17 shows the position and orientation of the IMU614E-P

13. Select accessories

	
IMU614E-X Test baseplate (older baseplate)	IMU614E-X Test baseplate (New baseplate)
	
Patch 485 version IMU614E Series	Patch TTL Version IMU614E Series
	
Type-c wire	TTL serial cable

14. Update records

Versions	Dates	Status/Comments
Version 1.0	2023.08.23	First issue
Version 1.1	2023.10.07	Update coordinate system definition
Version 1.2	2023.10.17	Added Output protocol configuration instruction
Version 1.3	2023.11.22	Added attitude Angle and query configuration
Version 1.4	2024.01.16	Add attachments
Version 1.5	2024.02.04	Updating electrical characteristics
Version 1.6	2024.02.27	Updated reflow curve and ESD protection matters
Version 1.7	2024.06.07	Update Output Protocol
Version 1.8	2024.11.06	Add system status table, refine coordinate system description