FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-G

Product manual



Forsense (Shanghai) Technology Co., Ltd

Please read this user manual carefully before using this product.

FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-G-Product Manual(en)

Features

Tactical-Grade MEMS Gyroscope

- 5.0°/hr Bias instability
- 0.5°/√hr Angle Random Walk

Tactical-Grade MEMS Accelerometer

- 25μg Bias instability
- 0.035m/s /√hr Velocity Random Walk

independent rotary table calibration

- Independent calibration of each module: sensitivity, Bias, Misalignment
- -40°C to 85°C temperature compensation

High-intensity operating condition tolerance

- Extreme shock resistance: 2000g (0.5ms, half-sine, 3-axis)
- Extreme vibration resistance: 10g (10~2kHz, 3-axis)
- Stable operation across full temperature range: -40°C ~ 85°C
- 100% magnetic shielding

Real-time and flexible digital interface, compact size

- Configurable output sampling rate up to 1kHz
- Supports Serial Port, I2C, and SPI interfaces
- 14.7*17*3.7mm, weighing only 1.6g

Product Overview

IMU614E-G is a 6 degrees of freedom (DOF) MEMS inertial sensor module developed by Forsense Technology. It outputs tri-axis Gyroscope and acceleration data as standard.

High precision and resolution capture subtle vibrations and tilts. All modules undergo turntable calibration before shipment, ensuring stable performance under extreme conditions and high consistency across products.

Application Areas

- Applications with high heading accuracy requirements, such as lawn mowers and pool cleaning robots

In addition to standard performance and Parameter output, Forsense also provides**customized software and LOGO customization services**, supporting your product needs!

Table of Contents

1. Performance Parameter **3**
1.1 Gyroscope Key Metrics 3
1.2 Accelerometer Key Metrics 4
2. Physical Dimensions **6**
3. Electrical Characteristics **8**
3.1 Maximum Ratings 8
3.2 Operating Conditions 8
3.3 IO Threshold Characteristics 9
4. Pin Definition **10**
5. Recommended Reflow Oven Temperature Profile **12**
6. ESD Protection **14**
7. Communication Protocol **15**
8. Coordinate System Definition **16**
9. Usage Example **18**
9.1 Device Installation 18
9.2 Connection PC software Example 21
10. Packaging **23**
10.1 Tape-and-Reel Packaging 23
10.2 carrier tape 24
11. Optional Accessories **25**
12. Revision History **27**

Forsense (Shanghai) Technology Co., Ltd

1. Performance Parameter

1.1 Gyroscope Key Metrics

Table 1 Gyroscope Key Metrics

Parameter	Test Conditions / Remarks	Min	Typical	Max	Unit
Measurement Range			±300		°/s
Bias instability[1]	@25℃, Allan Variance, 1σ		5		°/hr
Bias stability	GJB, 10s Smoothing		XY: 15 Z: 10		°/hr
Bias Repeatability	GJB		XZ: 40 Y: 65		°/hr
Resolution			0.01		°/s
Misalignment between axes			0.02		deg
Internal low-pass cutoff frequency	Software Adjustable		50		Hz
ODR			100	1000	Hz
measure delay			10		ms
Bias over temperature	-40℃ ~ 85℃, ≤1℃/min @1σ		XZ: 0.1 Y: 0.15		°/s
Random Walk[1]	@25℃, Allan Variance, 1σ		0.5		°/√hr
scale coefficient error			XY: 2.5 Z: 0.6		‰
scale factor nonlinear			50		ppm

Note 1: IEEE standard, derived from the Allan variance curve under static conditions at 25°C

1.2 Accelerometer Key Metrics

Table 2 Accelerometer Key Metrics

Parameter	Test Conditions/Remarks	Min	Typical	Max	Unit
Measurement Range			±16		g
Bias instability[1]	@25℃, Allan Variance, 1σ		25		μg
Bias stability	GJB, 10s Smoothing		XY: 45 Z: 80		μg
Bias Repeatability	GJB		0.5		mg
Resolution			0.5		mg
Misalignment between axes			0.02		deg
Internal low-pass cutoff frequency	Software Adjustable		50		Hz
ODR			100	1000	Hz
measure delay			10		ms
Bias over temperature	-40℃ ~ 85℃, ≤1℃/min @1σ		XY: 0.8 Z: 1.2		mg
Random Walk[1]	@25℃, Allan Variance, 1σ		XY: 0.035 Z: 0.045		m/s/√hr
scale coefficient error			XY: 0.2 Z: 0.8		‰
scale factor nonlinear	@25℃		40		ppm

Note 1: IEEE standard, provided by the Allan variance curve in a static environment at 25°C

Figure 1 Typical Curve of Gyroscope Allan Variance

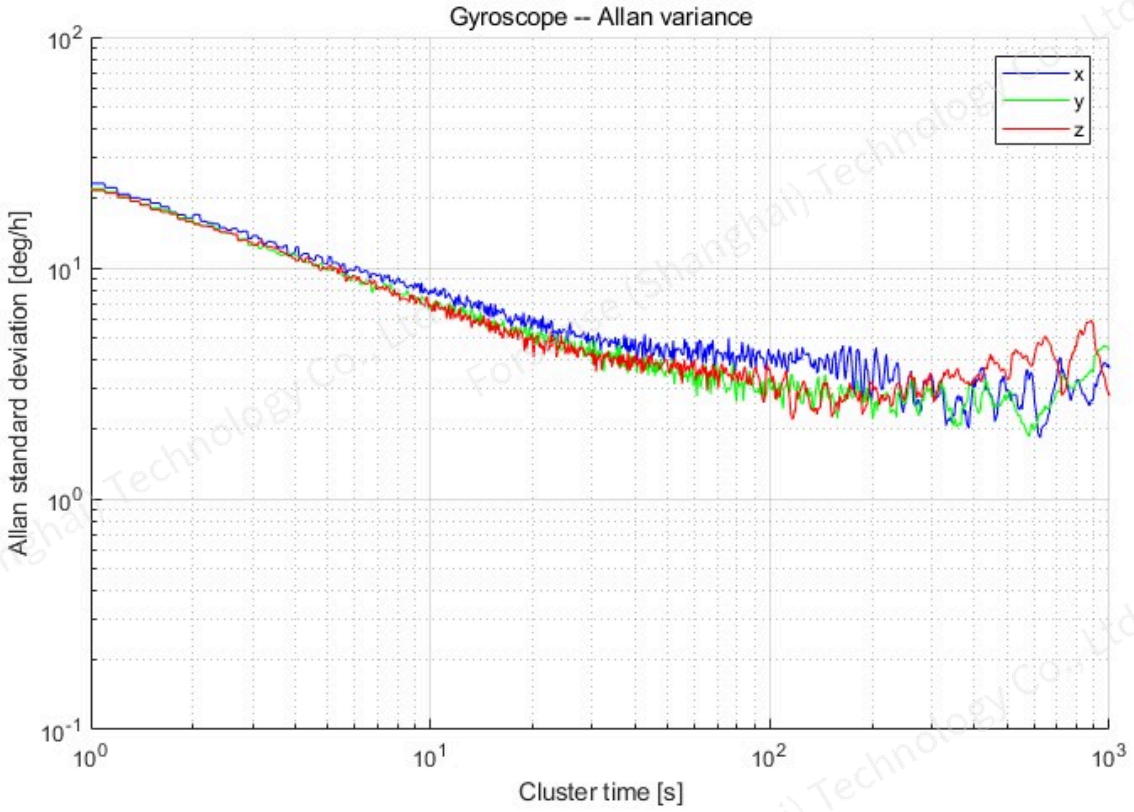
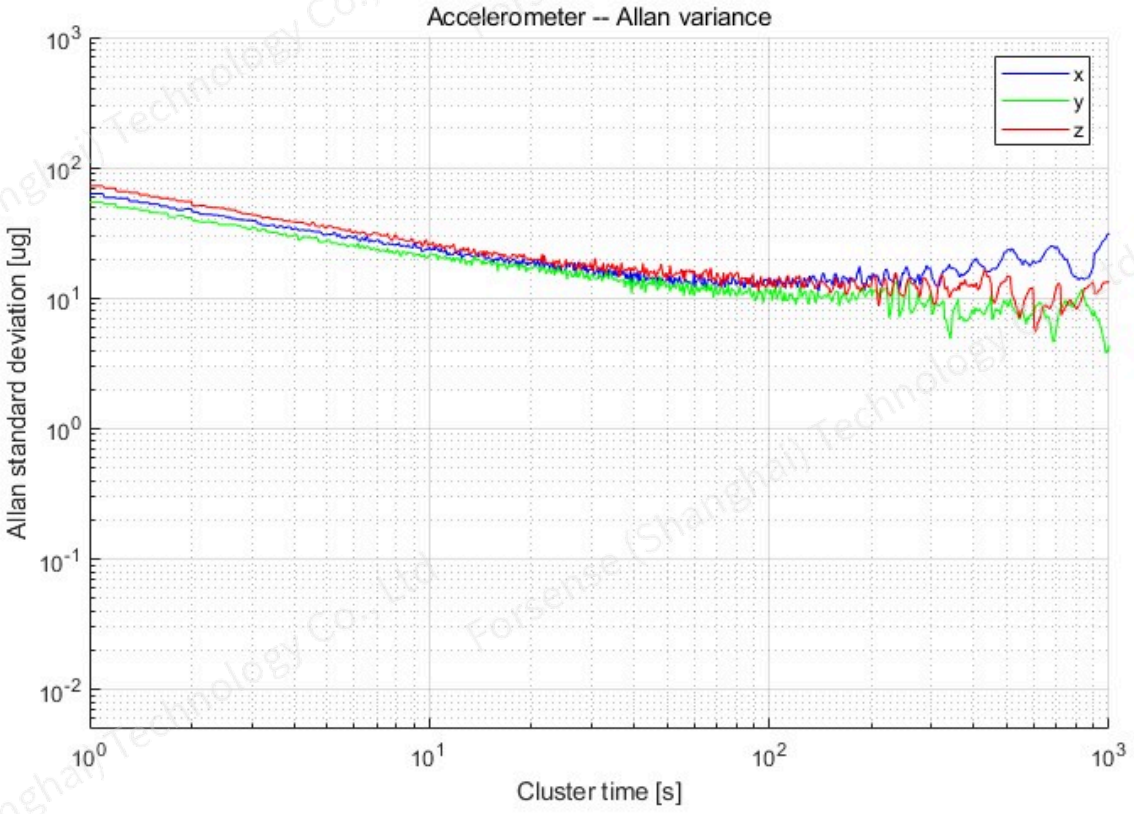


Figure 2 Typical Curve of Accelerometer Allan Variance



2. Physical Dimensions

Figure 3 Outline Structure and Dimensions (Unit: mm)

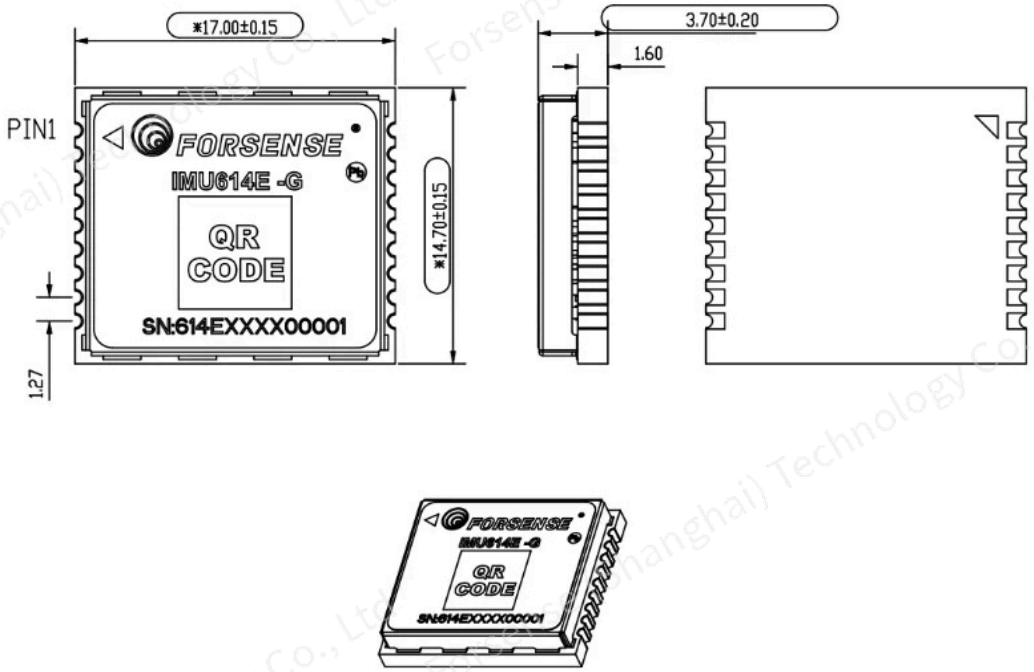


Figure 4 IMU Coordinate Center (Unit: mm)

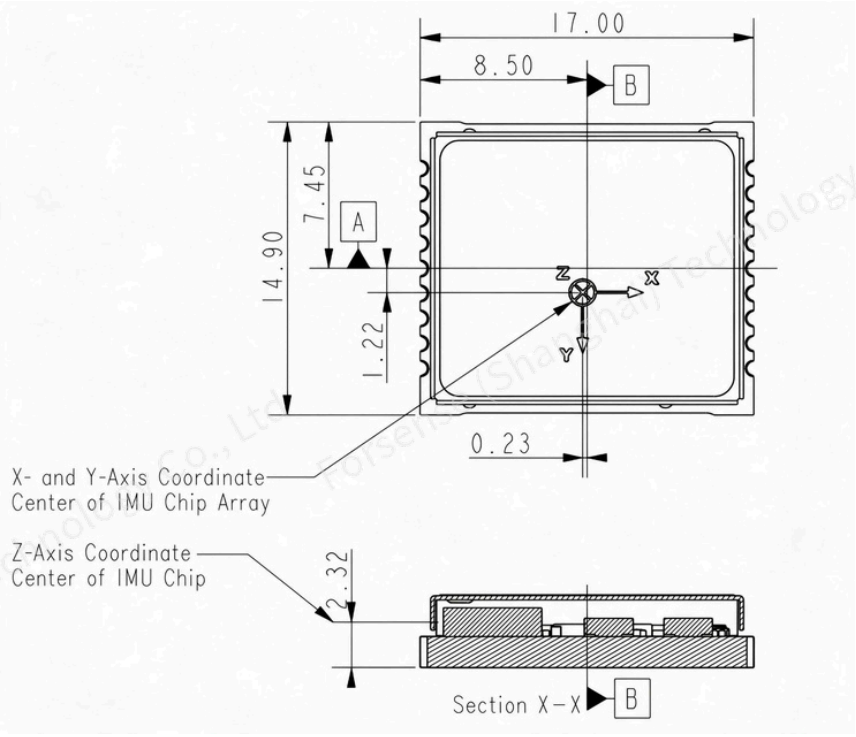
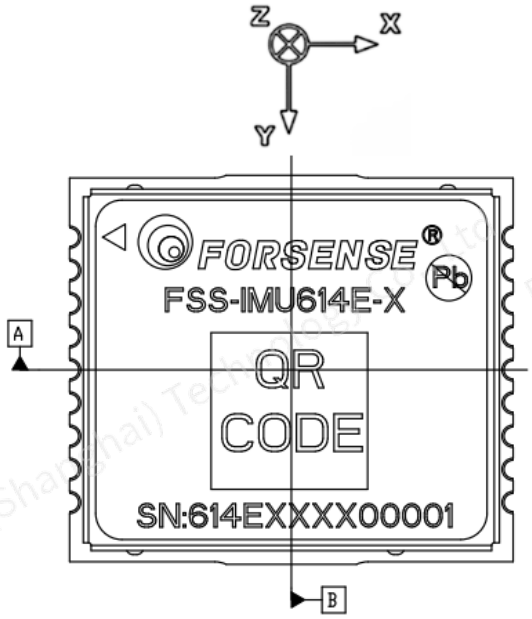
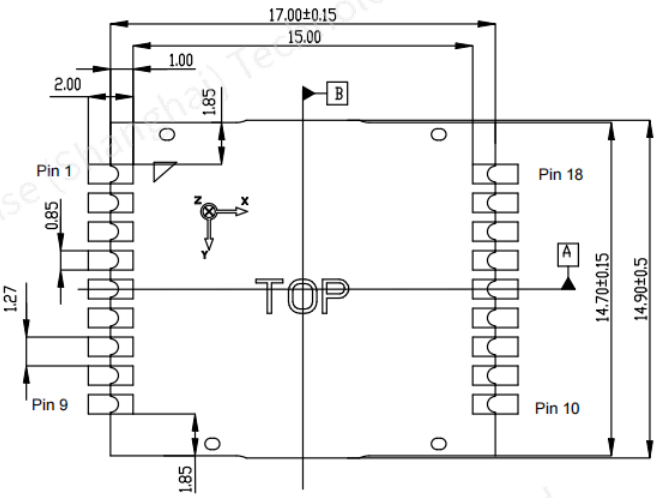


Figure 5 Recommended Pad Size (Unit: mm)





3. Electrical Characteristics

3.1 Maximum Ratings

Table 3 Absolute Maximum Ratings

Parameter	Symbol	Measurement Range	Unit
supply voltage	VCC	-0.3 to 4	V
Ground (GND)	GND	-	-
Input Pin Voltage (Vin)	Vin	-0.3 to VCC+0.2	V
Operating Temperature (Tot)	Tot	-40 to 85	℃
Storage Temperature (Tstg)	Tstg	-40 to 85	℃

3.2 Operating Conditions

Table 4 Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
supply voltage	VCC	3.2	3.3	3.4	V
Maximum VCC Ripple	Vrpp		±40		mV
Power Consumption	P		0.1		W
Operating Temperature (Tot)	T	-40		85	℃
Storage Temperature (Tstg)	T	-40		85	℃

3.3 IO Threshold Characteristics

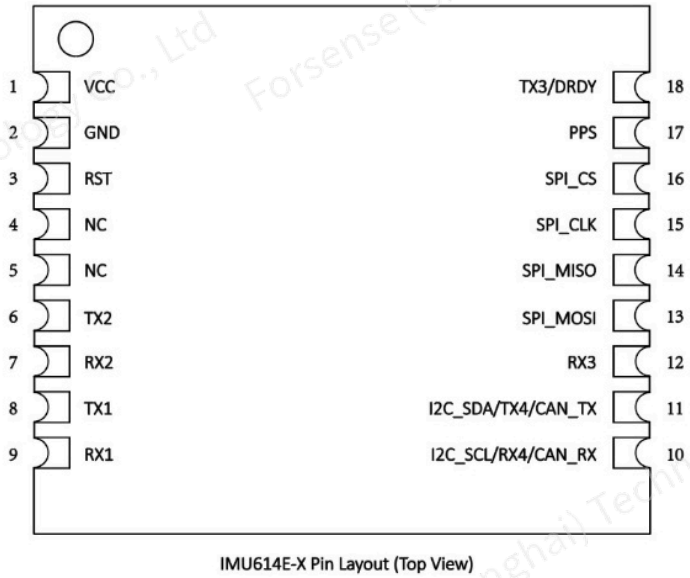
Table 5 IO Threshold Characteristics

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Input Pin Low Level	Vin_low	0		VCC*0.2	V
Input Pin High Level	Vin_high	VCC*0.7		VCC+0.2	V
Output Pin Low power level	Vout_low	0		0.45	V
Output Pin High power level	Vout_high	VCC-0.45		VCC	V

Forsense (Shanghai) Technology Co., Ltd

4. Pin Definition

Figure 6 Pin Schematic Diagram



IMU614E-X Pin Layout (Top View)

Table 6 Pin Definition

Pin Serial No.	Pin Name	Pin Description
1	VCC	Power Input, +3.3V Input, 40mA, Ripple ≤ ±40mV
2	GND	Ground (GND)
3	RST 1	External Hardware Reset Input, Internal Pull-up (for SPI Mode)
4	NC	No Connection
5	NC	No Connection
6	TX2	Receive asynchronous data Output
7	RX2	Receive asynchronous data Input
8	TX1	Receive asynchronous data Output (Data Communication Interface (LVTTL))
9	RX1	Receive asynchronous data Input (Data Communication Interface (LVTTL))

10	CAN RX / RX4 / I2C_SCL	Mode	Function	Description
		1	CAN_RX	CAN Receive Pin; reads data from the bus to the CAN controller
		2	RX4	Receive asynchronous data Input
		3	I2C_SCL	I2C serial clock
11	CAN TX / TX4 / I2C_SDA	Mode	Function	Description
		1	CAN_TX	Send CAN Pin; read data from the CAN controller to 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 chip select		
17	PPS	External Synchronous Sampling Trigger Signal; (Connected to RTK PPS Pin)		
18	TX3/DRDY	Receives asynchronous data Output / Can Be Used for Data Ready		

Note 1: When Master initialize, Use /RST to Reset the IMU Hardware Once

For hardware design information related to the module, refer to the document《IMU614E-XX Hardware Design Manual》.

5. Recommended Reflow Oven Temperature Profile

Figure 7 Reflow Oven Temperature Profile

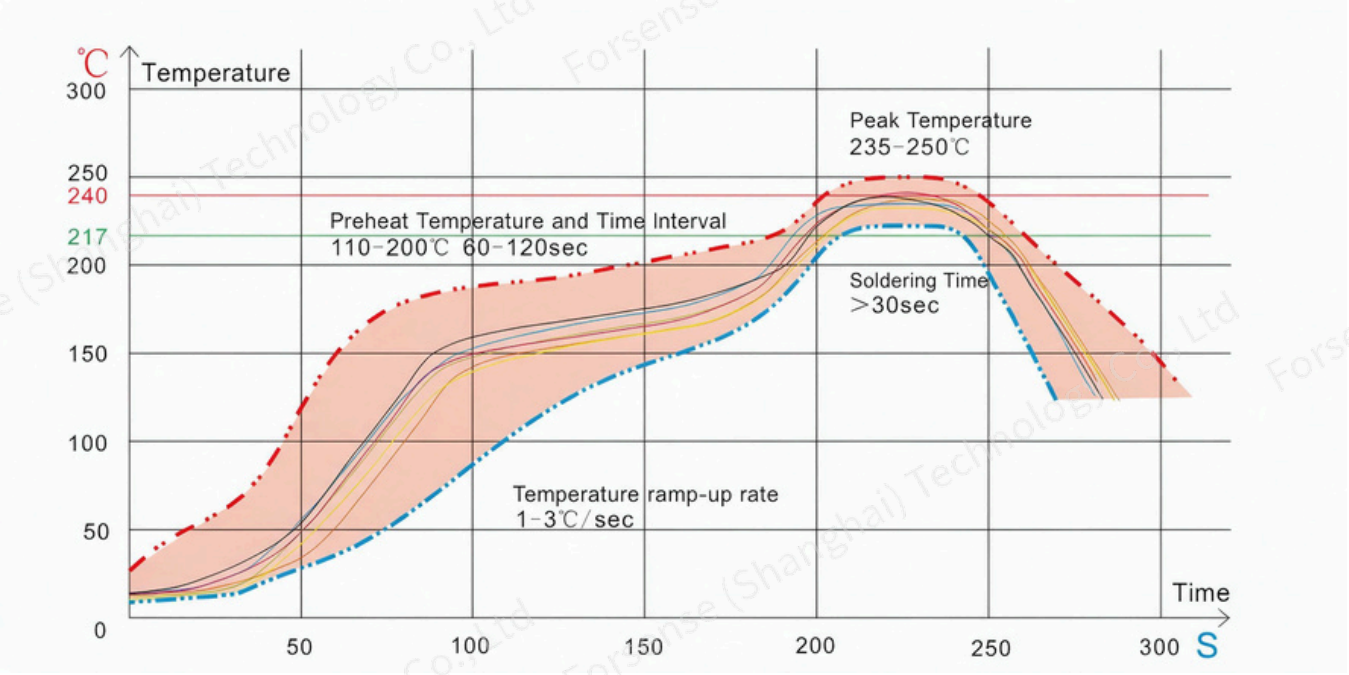


Table 7 Temperature Setting Modes

Item	Lower Limit	Upper Limit	Unit
Maximum Temperature Ramp Rate (Target = 0.8) (Time interval for slope calculation = 60 s)	1	3	°/s
Maximum Temperature Drop Slope (Time interval for slope calculation = 60 s)	-3	-1	°/s
Preheat Temperature and Time Interval	60	120	s
Reflow Time (Duration Above 217°C)	40	70	s
Maximum Temperature	235	250	°C
Maximum Number of Reflow Cycles		1	cycles

For more SMT-related information about the module, refer to the document《Forsense-LCC Module_SMT Application Guide》.

Notes:

- For module reflow soldering, it is recommended to use eight temperature zones or higher reflow soldering equipment;
- Since the module is a high-precision sensor product, it is sensitive to any deformation:
- If the PCB thickness is less than 1.0 mm, it is recommended to fabricate reflow fixture to prevent PCB deformation at high temperatures, which may affect the coplanarity of the soldering.
- It is recommended that customers select PCB mainboards with high TG values to avoid deformation during high-temperature reflow, which can cause warping, compression, cold joints, and bridging defects.
- Due to sensitive components inside the module, the maximum temperature of the customer's reflow oven must not exceed 260°C (referring to the package top temperature measured on the package surface).
- It is recommended to use lead-free no-clean solder paste. Recommended solder paste brand and model: Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5
- Due to sensitive components inside the module, secondary reflow should be avoided to prevent degradation of module performance;
- Cooling:
- Controlled cooling ramp rate prevents adverse soldering effects (such as brittle joints) and internal mechanical stress. Controlled cooling helps achieve bright solder surfaces, fine crystal grains, and low contact angles, while avoiding shielding can warping caused by rapid temperature drops.
- Visual Inspection:
- After module soldering, inspect soldering quality using X-ray and optical magnification methods, in accordance with relevant IPC-A-610F standards.
- **When soldering with a soldering iron, control the temperature between 260°C and 290°C, limit single soldering time to no more than 3 s, and ensure proper ESD protection.**

6. ESD Protection

Figure 8 ESD Protection



Static electricity causes intermittent or permanent circuit damage, posing significant risks to electronic products; analysis indicates that most such issues are ESD damage;

Therefore, electrostatic protection for the module is critical. Production and transportation must strictly follow ESD protection procedures, adhering to the following conditions:

- Bare-hand contact with the module is strictly prohibited, especially at Pin.
- Equipment such as SMT placement machines, workbenches, and soldering irons must be grounded.
- Personnel must wear anti-static wrist straps with proper grounding wires (cordless wrist straps are not allowed; anti-static gloves are recommended).
- Packaging and PCBs must be made of qualified anti-static materials.

7. Communication Protocol

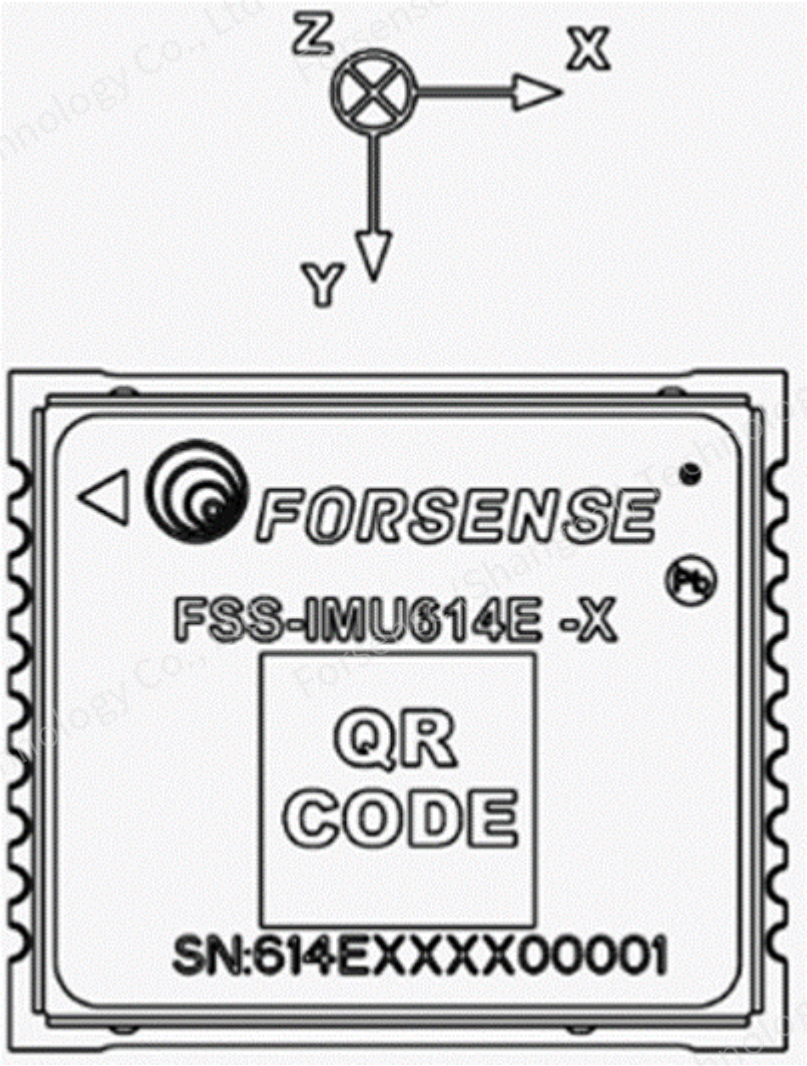
Reference Document Forsense IMU Communication Protocols（en）

Includes serial communication protocols, coordinate system settings, filter settings, Parameter settings, OTA update methods, time synchronization, etc.

Forsense (Shanghai) Technology Co., Ltd

8. Coordinate System Definition

Figure9 Coordinate System Definition



This product uses the Front-Right-Down (FRD) coordinate system. The Euler angle ranges are as follows:

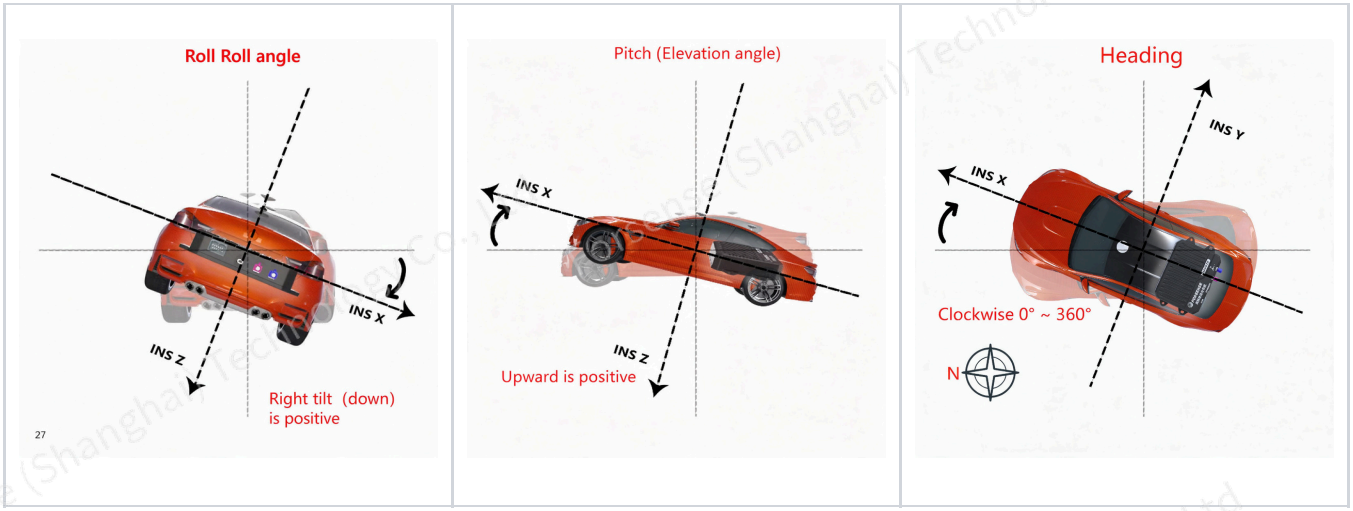
Rotation about the Z-axis: Yaw angle Yaw range: 0° ~ 360°

Rotation about the X-axis: Roll angle Roll range: -180° ~ 180°

Rotation about the Y-axis: Pitch angle Pitch range: -90° ~ 90°

The schematic diagram of Roll, Pitch, and Yaw angle is shown below:

Figure 10 Schematic of Roll, Pitch, and Yaw angle



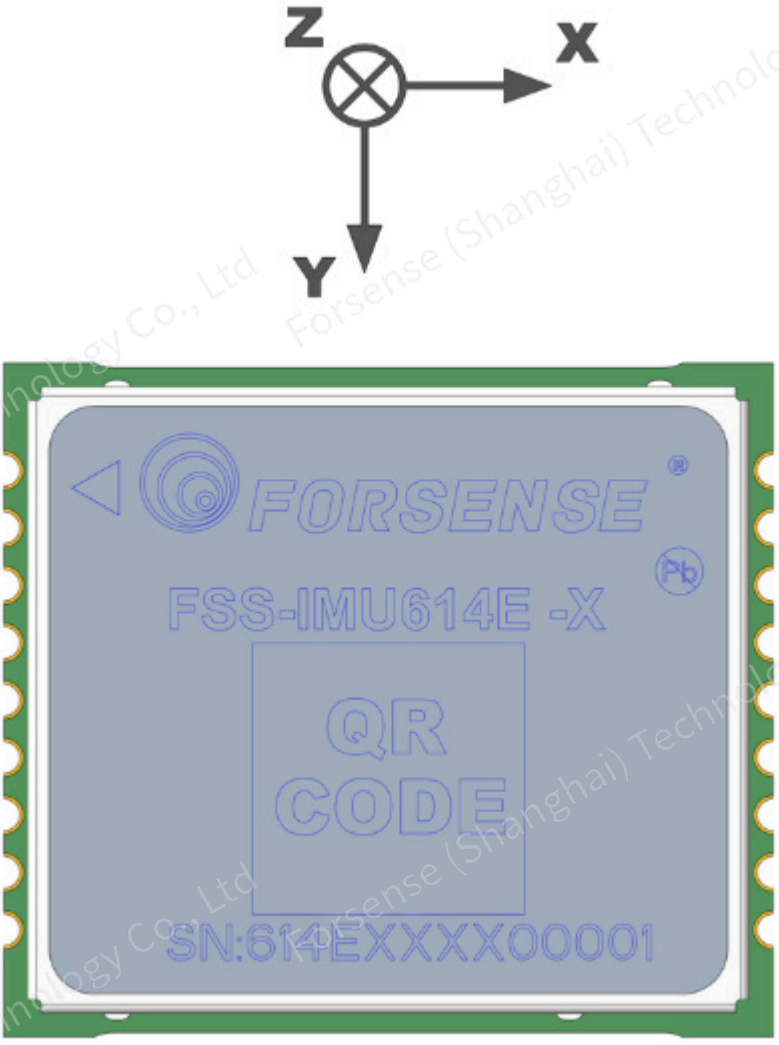
9. Usage Example

9.1 Device Installation

1. The module should be securely fixed to a rigid plane, avoiding installation in areas with high vibration.

2. The module's orientation should align with the vehicle's forward direction.

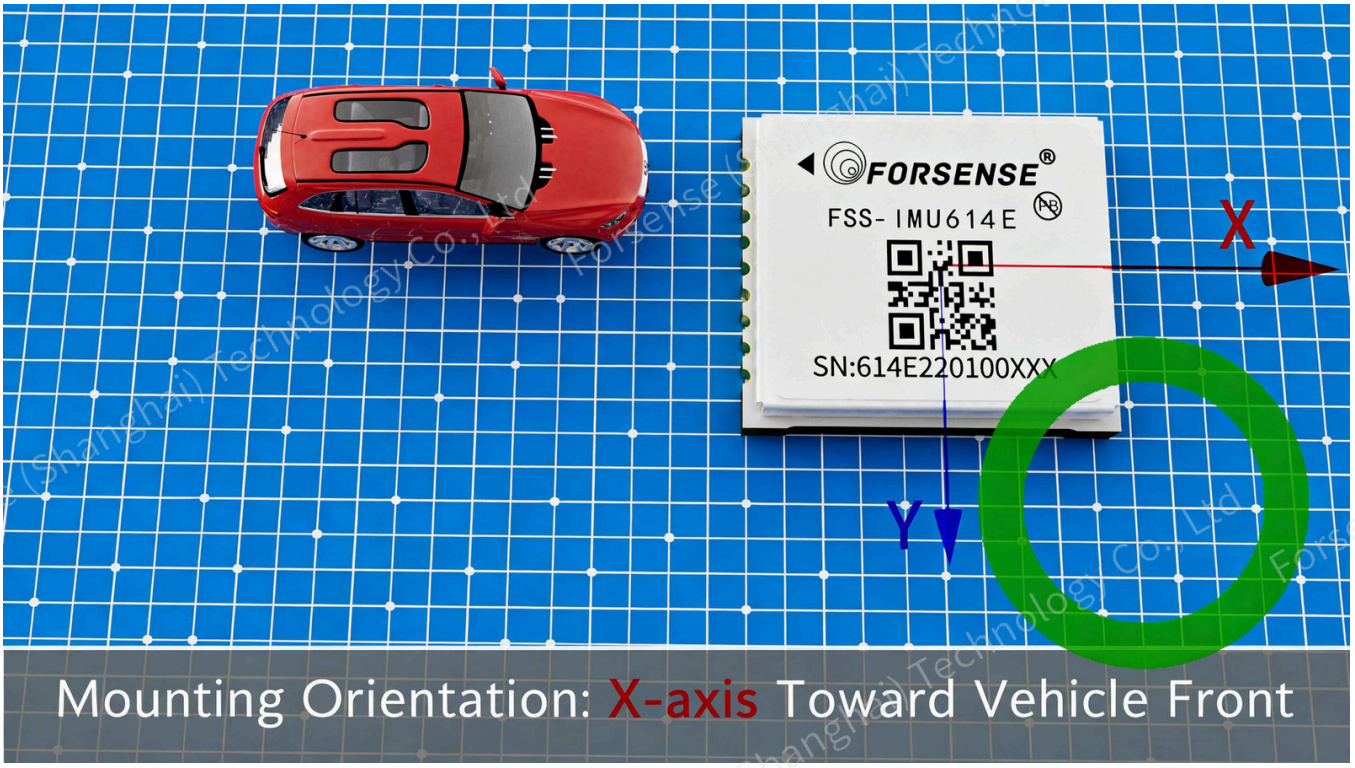
Figure11 Module Installation Diagram



The correct installation diagram is shown below

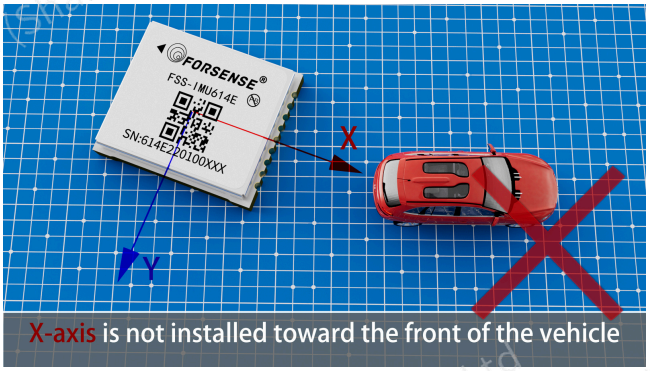
X-axis points toward the front of the vehicle

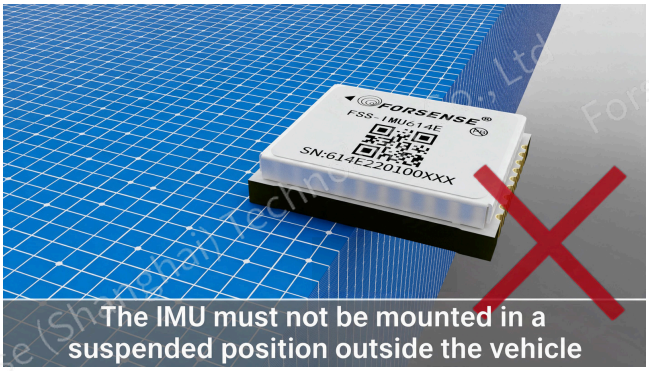
Figure 12 Correct Installation Diagram

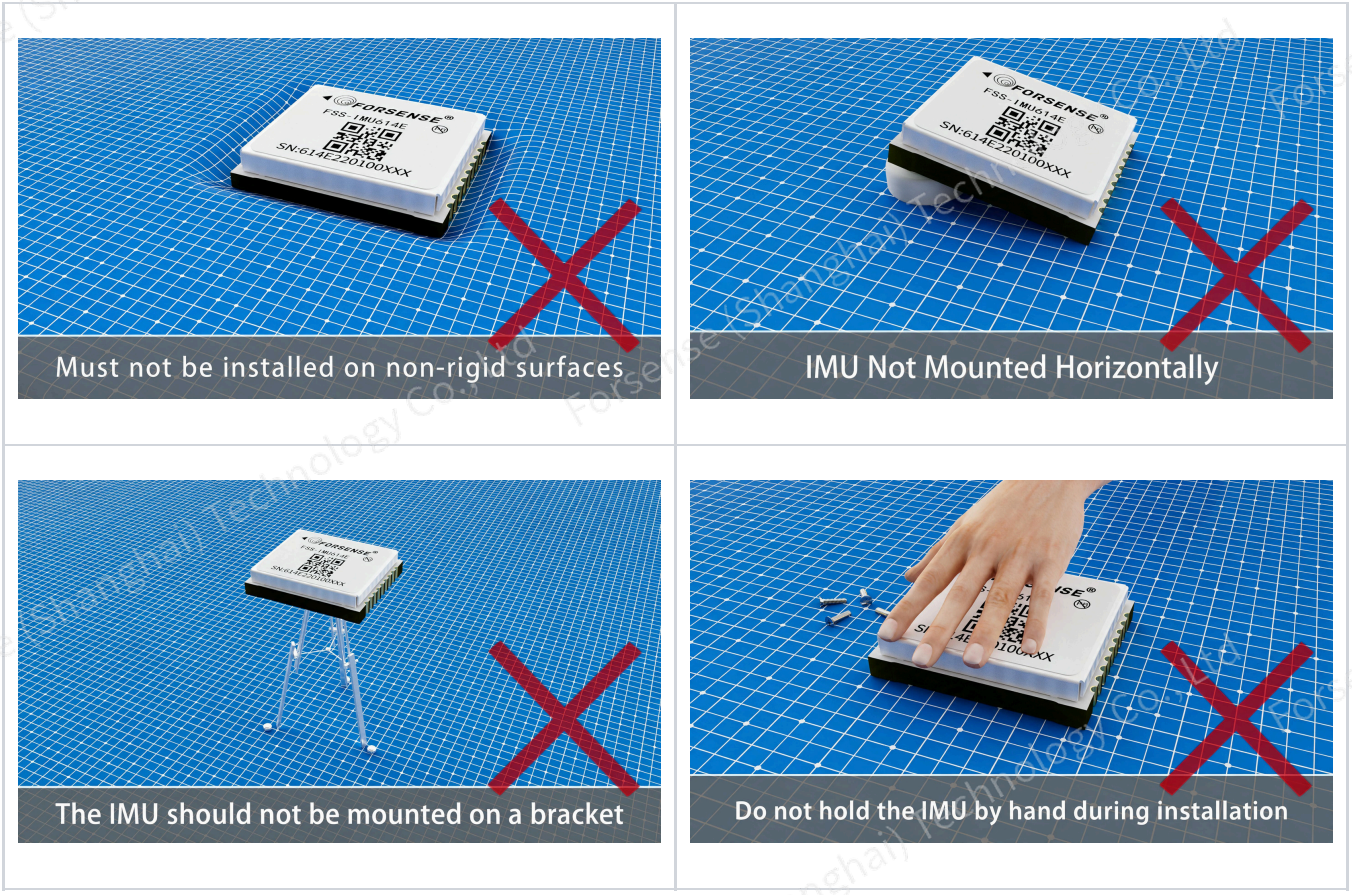


The following installation methods are all incorrect.

Figure 13 Incorrect Installation Diagram



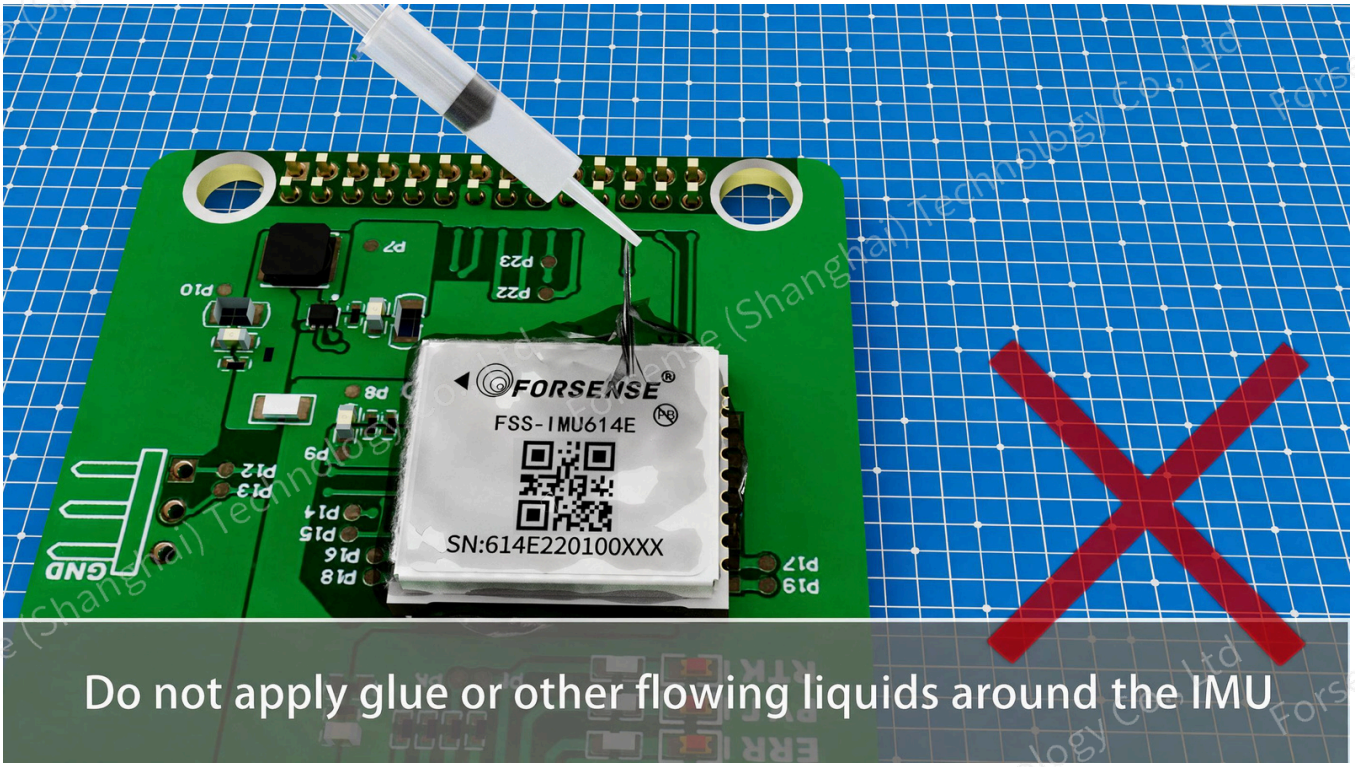




3. IMU Installation Precautions

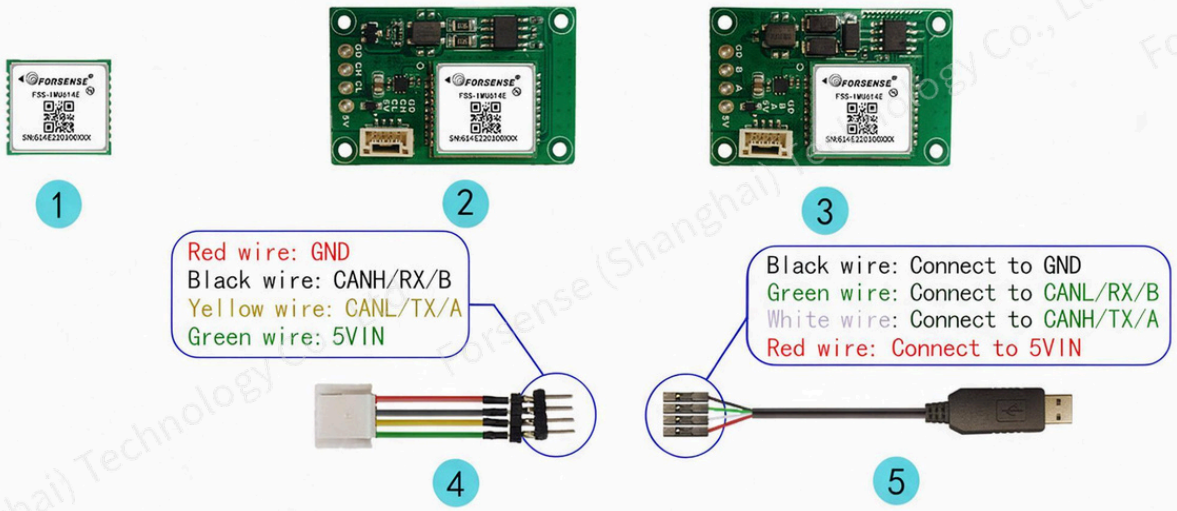
Do not apply adhesive or other flowing liquids around the IMU to prevent liquid from seeping into the IMU through gaps and affecting its performance.

Figure 14 Incorrect Installation Diagram



9.2 Connection PC software Example

Figure 15 Module Connection PC software Diagram



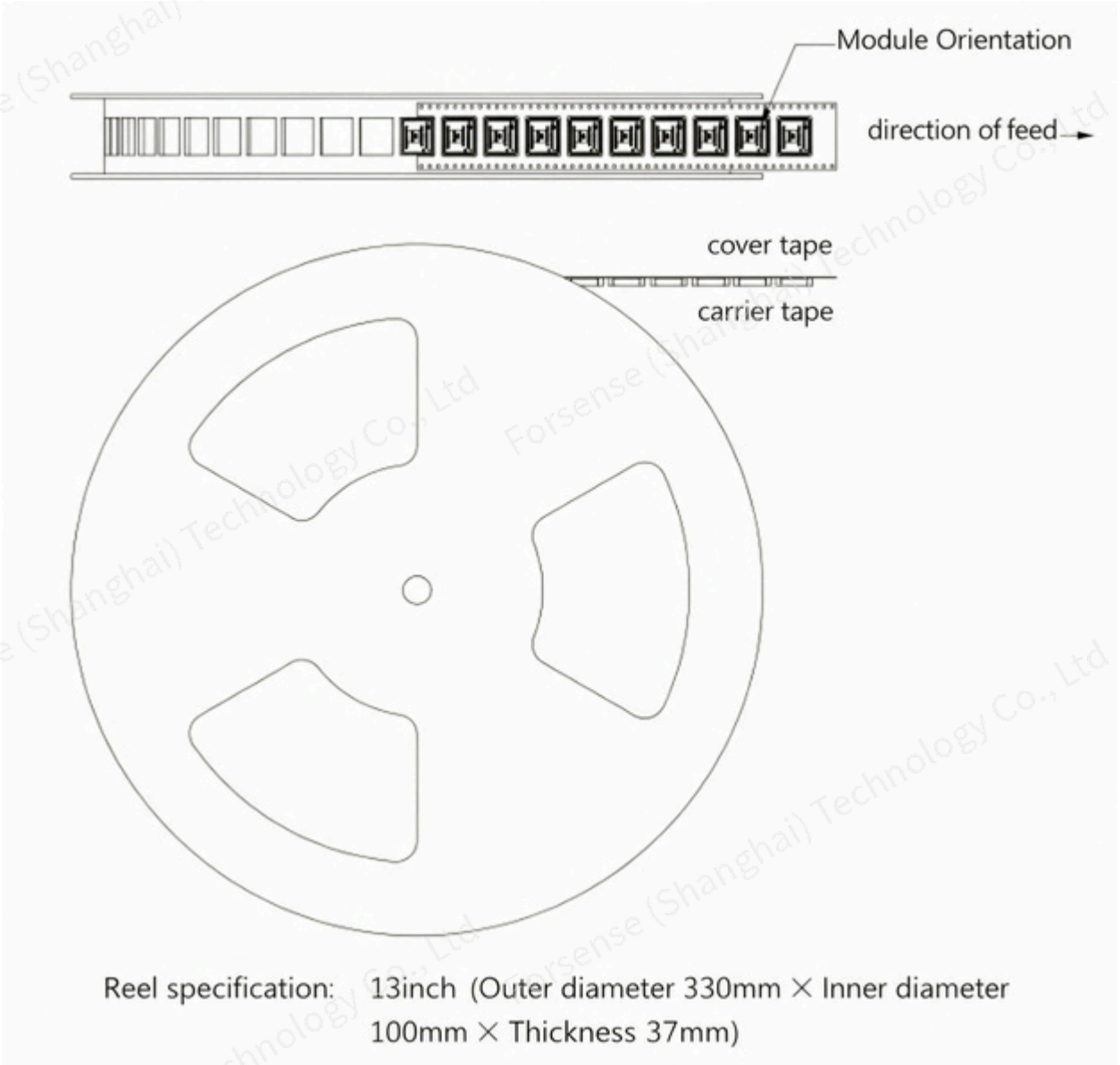
	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	SMD CAN Version Test Base Plate	1 pc
3	SMD 485 Version Test Base Plate	1 pc
4	4-PIN Connector	1 pc
5	TTL Serial Port Cable	1 pc

10. Packaging

The IMU614E-G module uses tape-and-reel sealed packaging to meet efficient production requirements.

10.1 Tape-and-Reel Packaging

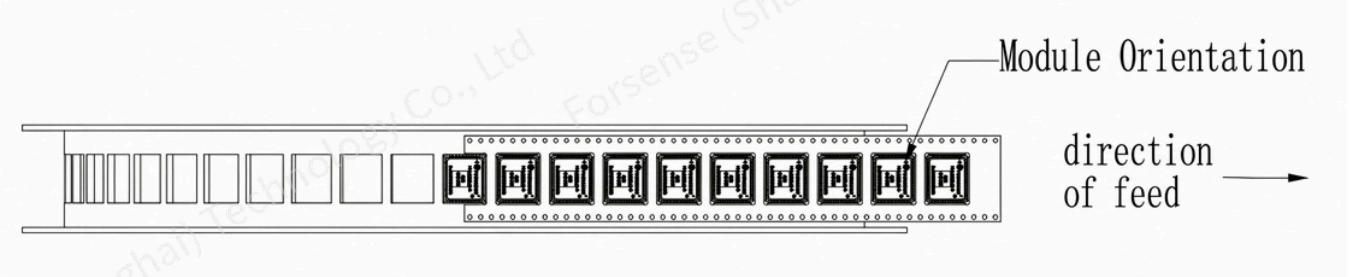
Figure 16 Tape-and-Reel Packaging Diagram



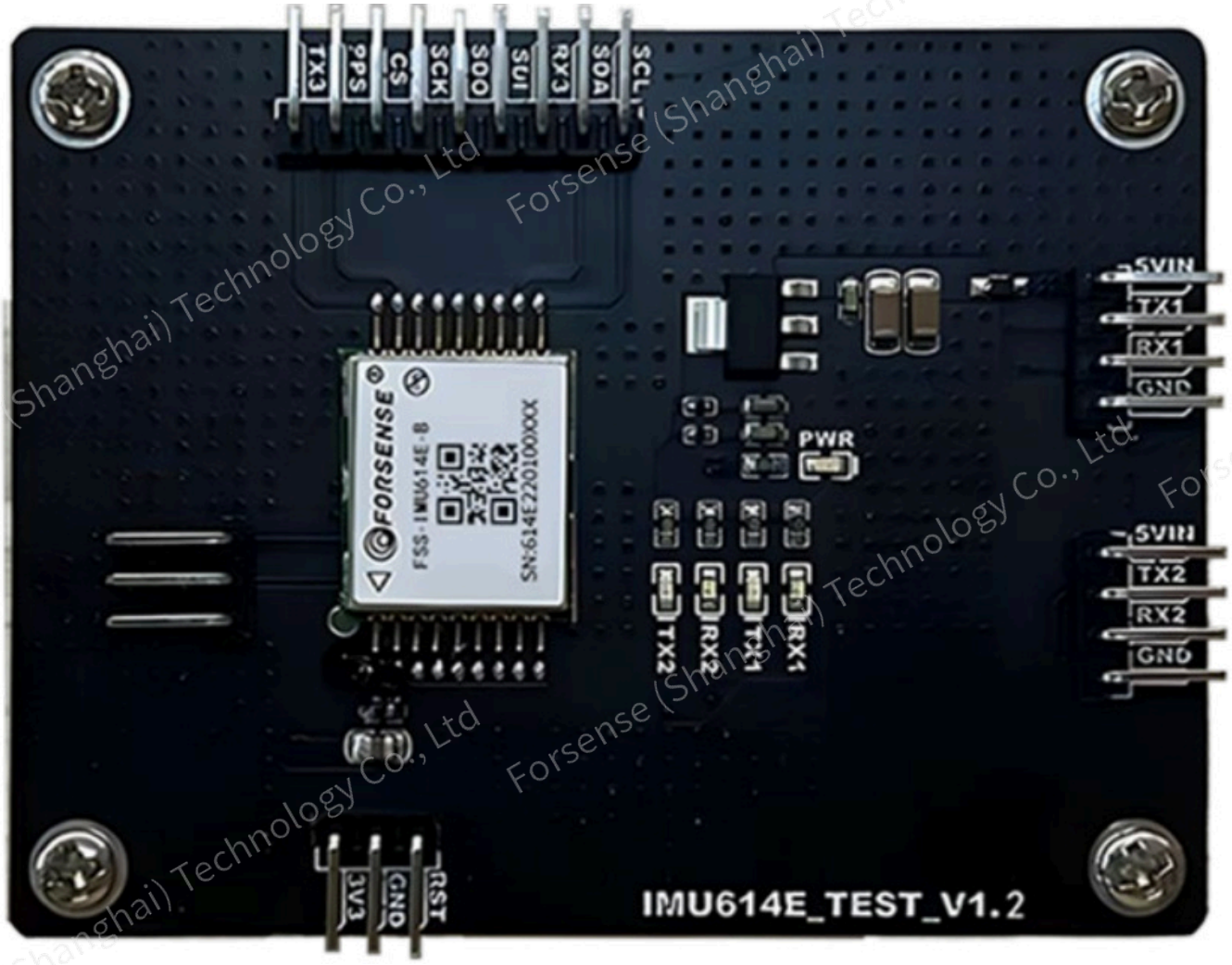
10.2 carrier tape

The position and orientation of the IMU614E-G module as placed on the carrier tape at factory shipment are shown in the figure below:

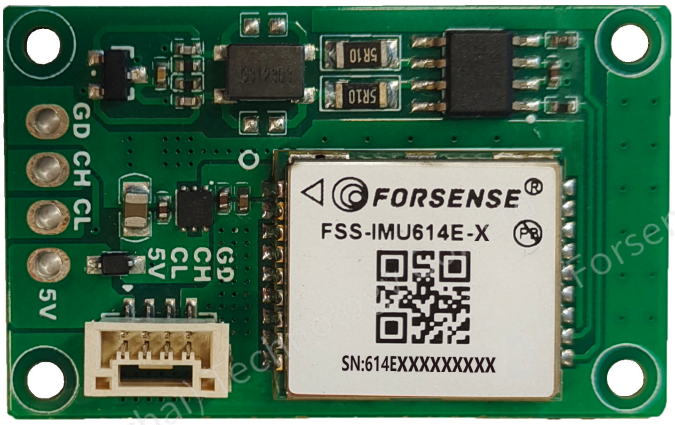
Figure 17 Module Position and Orientation at carrier tape

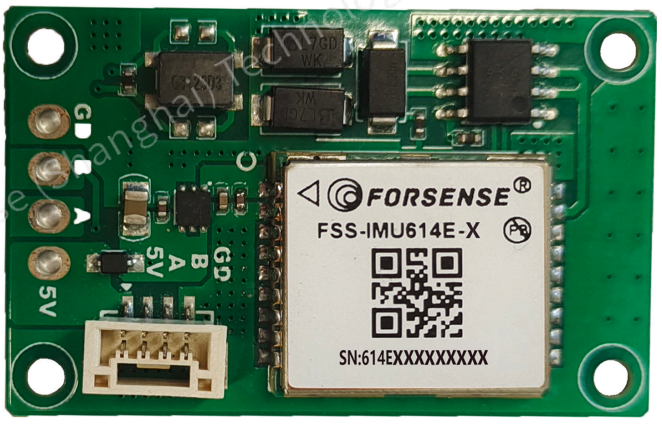


11. Optional Accessories



IMU614E-X Test Base Plate





SMD CAN Version IMU614E Series SMD RS-485 Version IMU614E Series





USB to CAN Module TTL Serial Port Cable

12. Revision History

Latest Manual Version: IMU614E-G_Datasheet_Product Manual(en)

Version	Date	Status/Notes
Version 1.0	2024.08.13	First Edition
Version 1.1	2025.01.23	Adjusted table and figure numbering
Version 1.2	2025.08.01	Simplified communication protocol
Version 1.3	2025.12.24	Removed TTL test Base Plate
Version 1.4	2026.2.10	Update "SMD CAN Version IMU614E Series Test Base Plate","SMD RS-485 Version IMU614E Series Test Base Plate", "Recommended Pad Dimensions"
Version 1.5	2026.3.5	Updated "Product Dimensions Diagram"