FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-Q

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-Q-Product Manual(en)

Features

Tactical-Grade MEMS Gyroscope

- 5°/hr Bias instability
- x:0.85°/√hr, yz:0.6°/√hr Angle Random Walk

Tactical-Grade MEMS Accelerometer

- 40ug Bias instability
- 0.09m/s /√hrVelocity 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

- Super shock resistance: 2000g (0.5ms, half-sine, 3-axis)
- Super 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*3.3mm, weighing only 2g

Product Overview

IMU614E-Q 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 high resolution capture subtle vibrations and tilts. All modules undergo turntable calibration before shipment, ensuring stable performance under extreme conditions and consistent product quality.

Application Areas

- Various robots: including AGVs, service robots, lawn mowers, pool robots, etc.

Based on standard performance and output Parameter, Forsense also provides for your special needs**Customized Software and Logo Customization Services**, helping you succeed with your products!

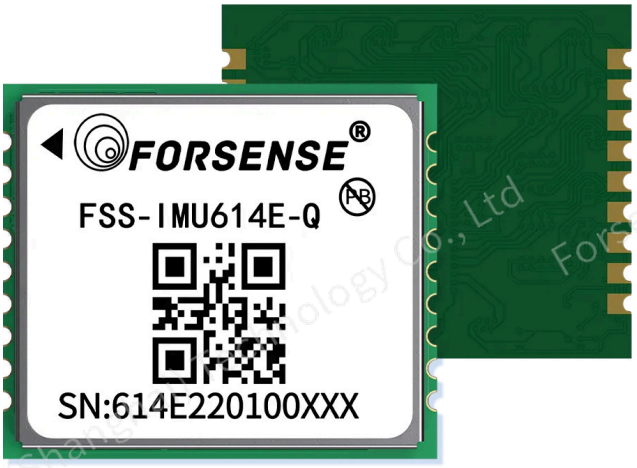


Table of Contents

1. Performance Parameter **3**
1.1 Gyroscope Key Specifications 3
1.2 Key Metrics for Accelerometer 4
2. Outline and Structure **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 Soldering Temperature Profile **13**
6. ESD ProtectionLevel and Protection **15**
6.1 ESD Protection Level 15
6.2 ESD Protection 15
7. Communication Protocol **16**
8. Coordinate System Definition **17**
9. Usage Examples **19**
9.1 Device Installation 19
9.2 Connection PC software Example 21
10. Packaging **23**
10.1 Tape-and-Reel Packaging 23
10.2 carrier tape 24
11. OptionalAccessories **25**
12. UpdateRecord **27**

Forsense (Shanghai) Technology Co., Ltd

1. Performance Parameter

1.1 Gyroscope Key Specifications

Table 1 Gyroscope Key Specifications

Parameter	Test Conditions/Notes	Min	Typ	Max	Unit
Measurement Range			±500		°/s
Bias instability[1]	@25,Allan Variance,1σ		5		°/hr
Bias stability	GJB, 10s Smoothing		x:15 yz:12		°/hr
Bias Repeatability	GJB		x:25 yz:12		°/hr
Resolution			0.0153		°/s
Misalignment between axes			0.05		deg
Internal low-pass cutoff frequency	Software Adjustable		116		Hz
ODR			1000		Hz
measure delay			3		ms
Bias over temperature[2]	-40 ~ 85℃,<=1℃/min @1σ		0.05		°/s
Random Walk[1]	@25,Allan Variance,1σ		x:0.85 yz:0.6		°/√hr
scale coefficient error	@25,1σ		3		‰
scale factor nonlinear			200		ppm

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

Note 2: 1σ value of Bias variation over the full temperature range at a heating rate of 1°C/min

1.2 Key Metrics for Accelerometer

Table 2 Key Metrics for Accelerometer

Parameter	Test Conditions / Remarks	Min	Typ	Max	Unit
Measurement Range			±6		g
Bias instability[1]	@25,Allan Variance,1σ		40		μg
Bias stability	GJB, 10s Smoothing		90		μg
Bias Repeatability	GJB		0.2		mg
Resolution			0.183		mg
Misalignment between axes			0.05		deg
Internal low-pass cutoff frequency	Software Adjustable		116		Hz
ODR			1000		Hz
measure delay			3		ms
Bias over temperature[2]	-40 ~ 85℃,<=1℃/min @1σ		1.5		mg
Random Walk[1]	@25,Allan Variance,1σ		0.09		m/s/√hr
scale coefficient error	@25,1σ		0.5		‰
scale factor nonlinear			300		ppm

Note 1: IEEE standard, Allan variance curve provided at static 25°C

Note 2: 1σ value of Bias variation over full temperature range at a heating rate of 1°C/min

Figure 1 Gyroscope Allan Variance Typical Curve

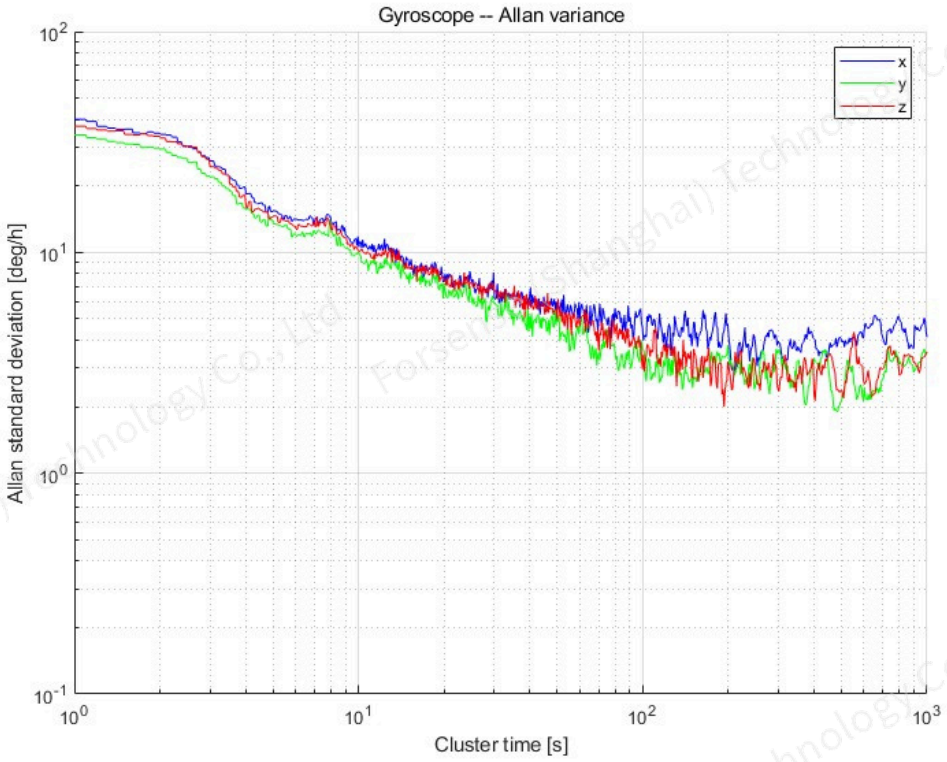
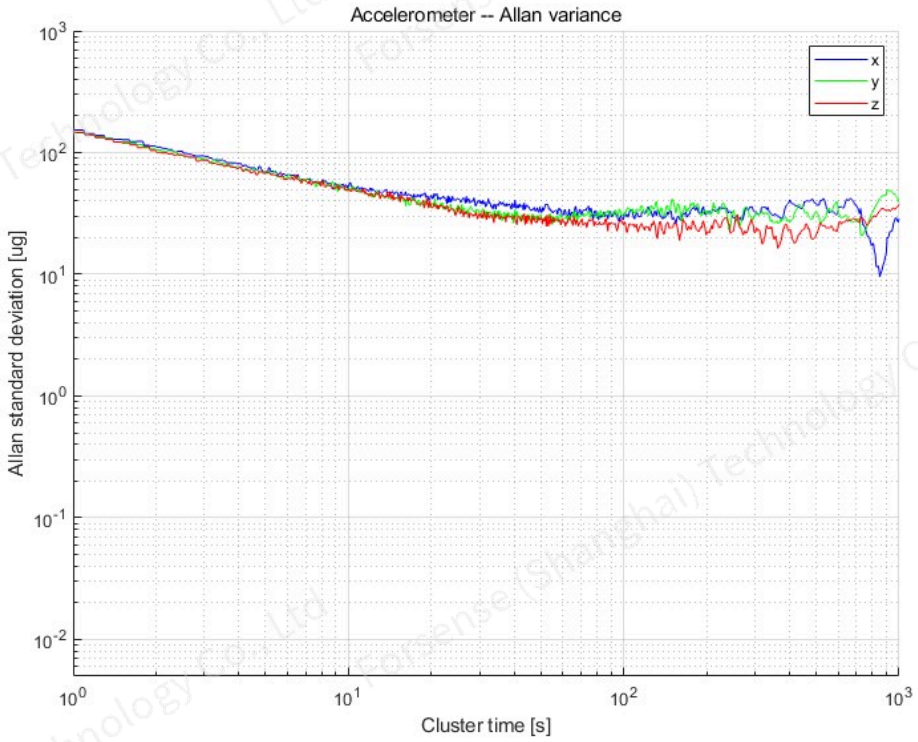
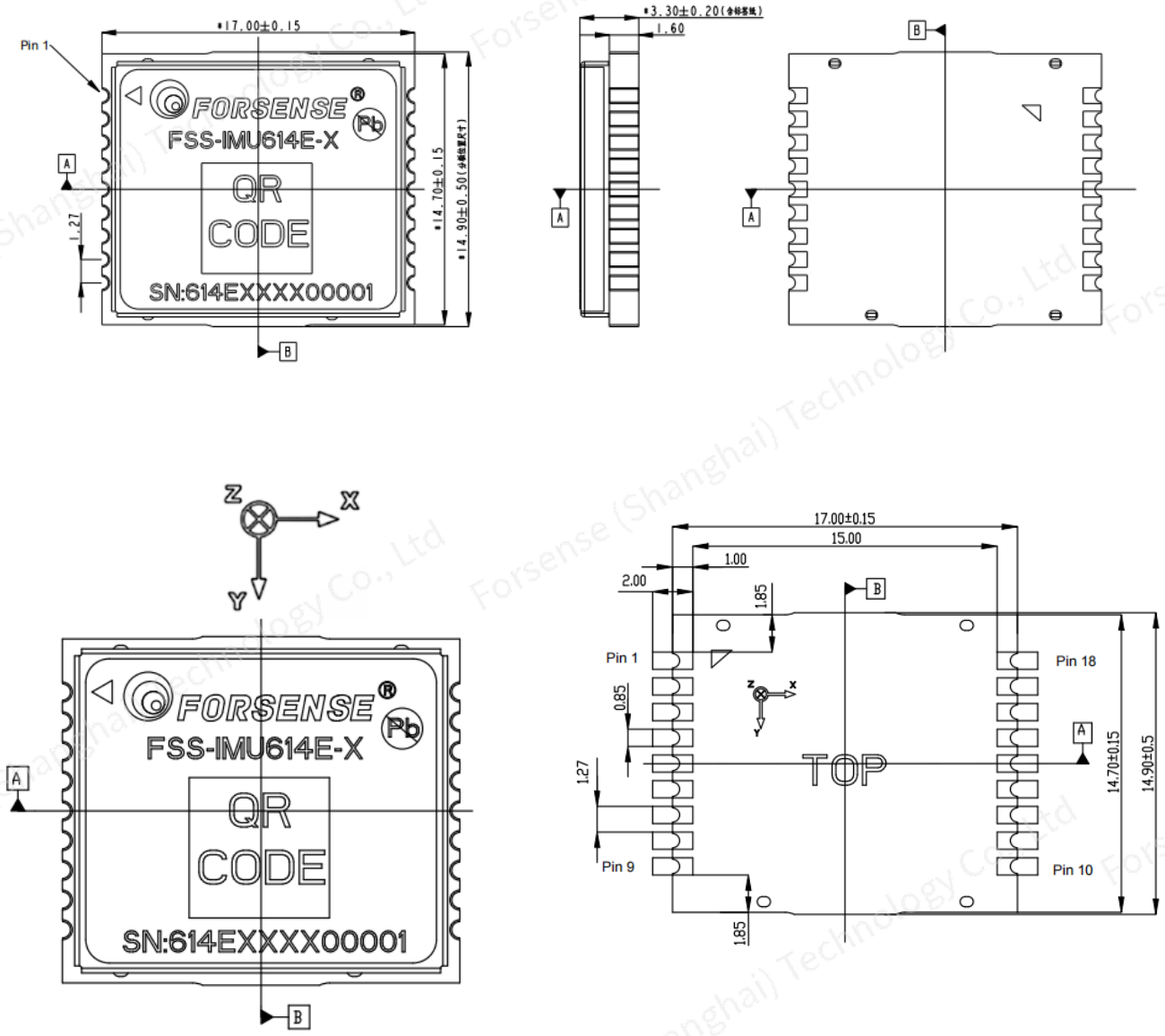


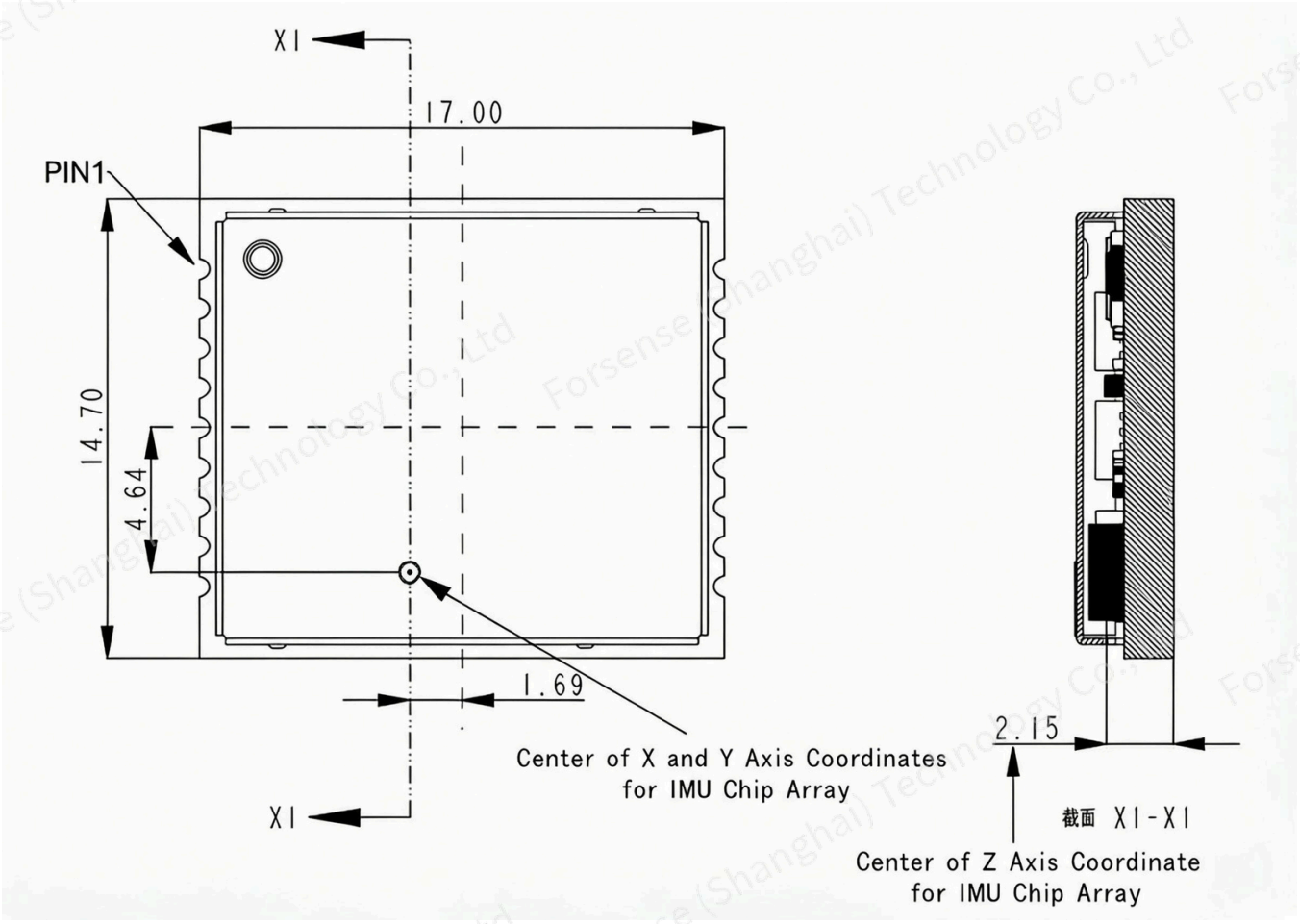
Figure 2 Accelerometer Allan Variance Typical Curve



2. Outline and Structure

Figure 3 Outline Structure andRecommended PadDimensions (Unit: mm)




X1
17.00
PIN1
14.70
4.64
1.69
X1
Center of X and Y Axis Coordinates
for IMU Chip Array
2.15
截面 X1-X1
Center of Z Axis Coordinate
for IMU Chip Array

3. Electrical Characteristics

3.1 Maximum Ratings

Table 3 Absolute Maximum Ratings

Parameter	Symbol	Range	Unit
supply voltage	VCC	-0.3 to 4.0	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
VCC Max Ripple	Vrpp		±40		mV
Power Consumption	P		0.08		W
Operating Temperature (Tot)	T	-40		85	℃
Storage Temperature (Tstg)	T	-40		85	℃

3.3 IO Threshold Characteristics

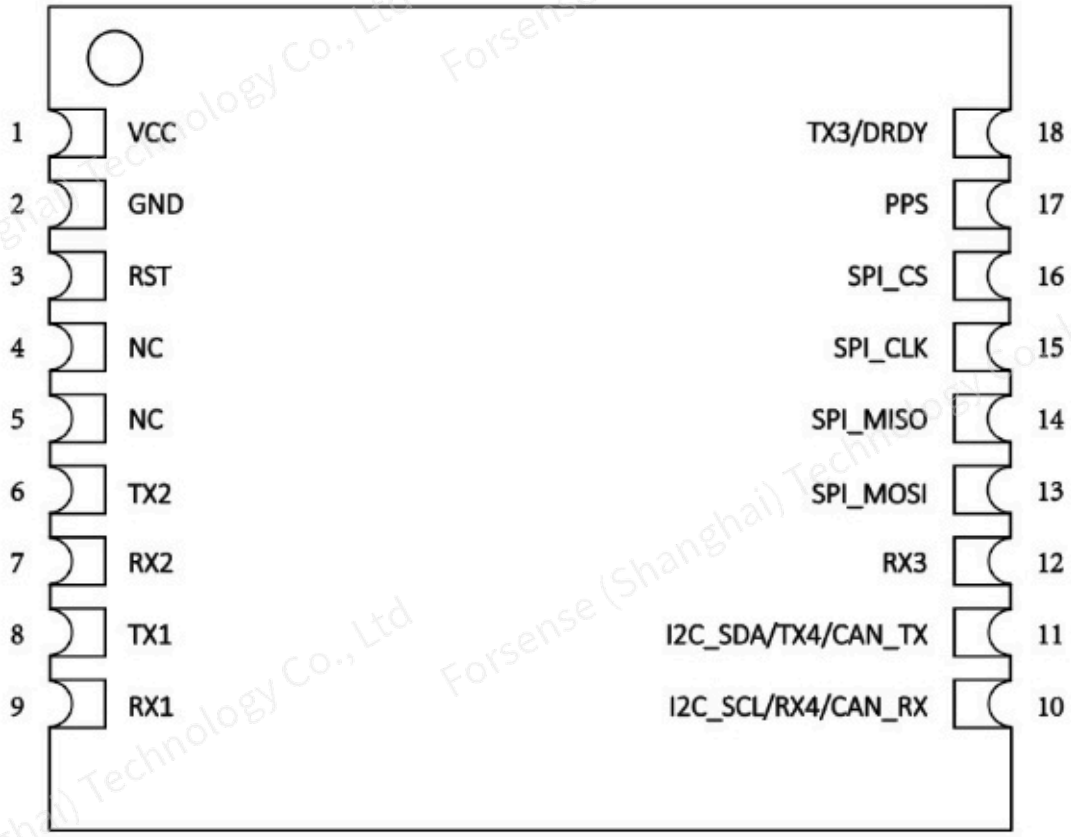
Table 5 IO Threshold Characteristics

Parameter	Symbol	Minimum	Typical Value	Maximum Value	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 4 Pin Schematic



IMU614E-X Pin Layout (Top View)

Table 6 Pin Definitions

Pin 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; Read 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	CAN Transmit 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; (Connect to RTK PPS Pin)
18	TX3/DRDY	Receives asynchronous data output / Available for Data Ready

Note 1: When Master initialize, use /RST to perform a hardware reset of the IMU once

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

5. Recommended Reflow Soldering Temperature Profile

Figure 5 Reflow Soldering Temperature Profile

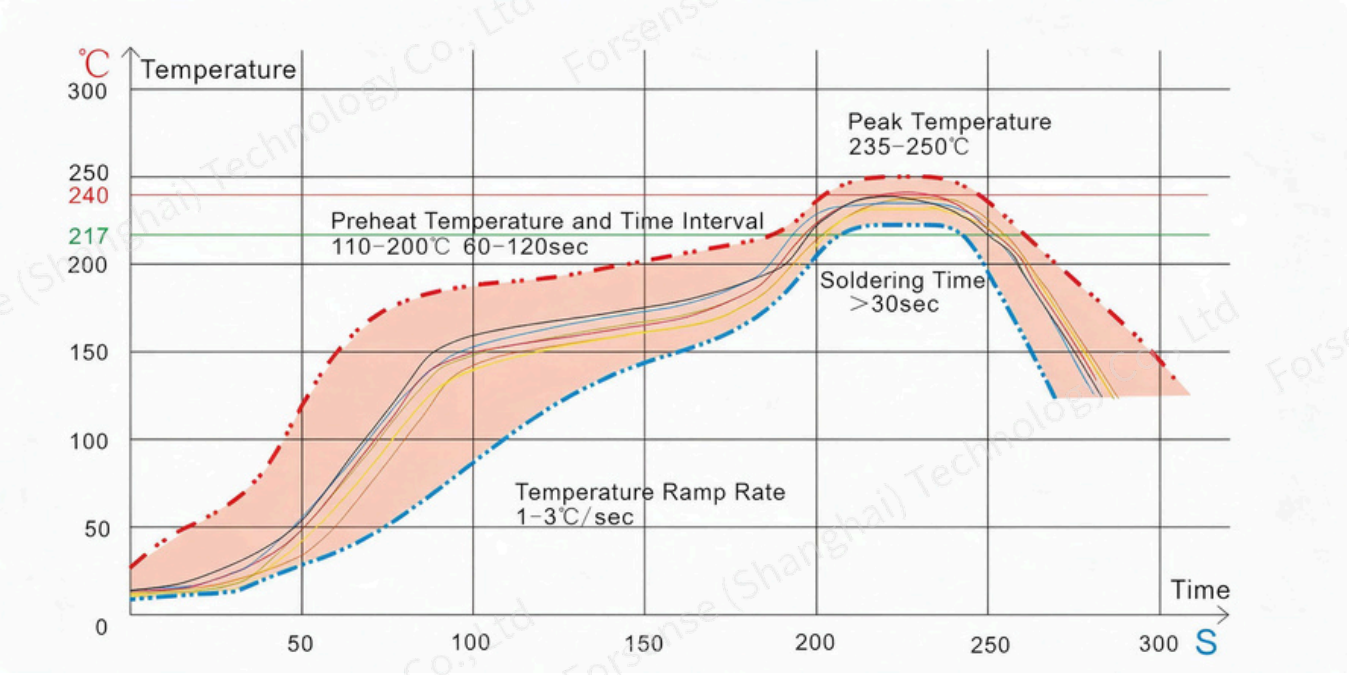


Table 7 Temperature Setting Mode

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

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 soldering coplanarity.
- It is recommended that customers select high-TG value materials for the main PCB to avoid deformation during high-temperature reflow, which can cause warping, compression, cold joints, and solder bridging.
- Due to sensitive components inside the module, the maximum temperature of the customer's reflow oven must not exceed 260 °C (referring to the top surface temperature measured on the package).
- Lead-free no-clean solder paste is recommended. 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 performance degradation;
- 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 cover warping caused by rapid temperature drops.
- Visual Inspection:
- After module soldering, inspect soldering quality using X-ray and optical magnification methods. Refer to the relevant IPC-A-610F standards for specific requirements.
- **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 ProtectionLevel and Protection

6.1 ESD Protection Level

Table 8ESD Protection Level

Parameter	Limit Values	Notes
ESD HBM	2KV	Reference Standard: JEDEC/ESDA JS-001

6.2 ESD Protection

Figure 6 ESD Protection



Electrostatic discharge causes intermittent or permanent circuit damage and poses significant risks to electronic products; analysis indicates that most cases are ESD damage;

Therefore, ESD protection for the module is critical. Production and transportation processes must strictly adhere to ESD protection protocols, following these conditions:

- Strictly prohibit bare-hand contact with the module, especially at Pin.
- Equipment such as SMT placement machines, workbenches, and soldering irons must be grounded.
- Operators must wear wrist straps with good grounding wires (cordless ESD wrist straps are not allowed; anti-static gloves are recommended).
- Packaging and PCBs must be made of qualified anti-static materials.

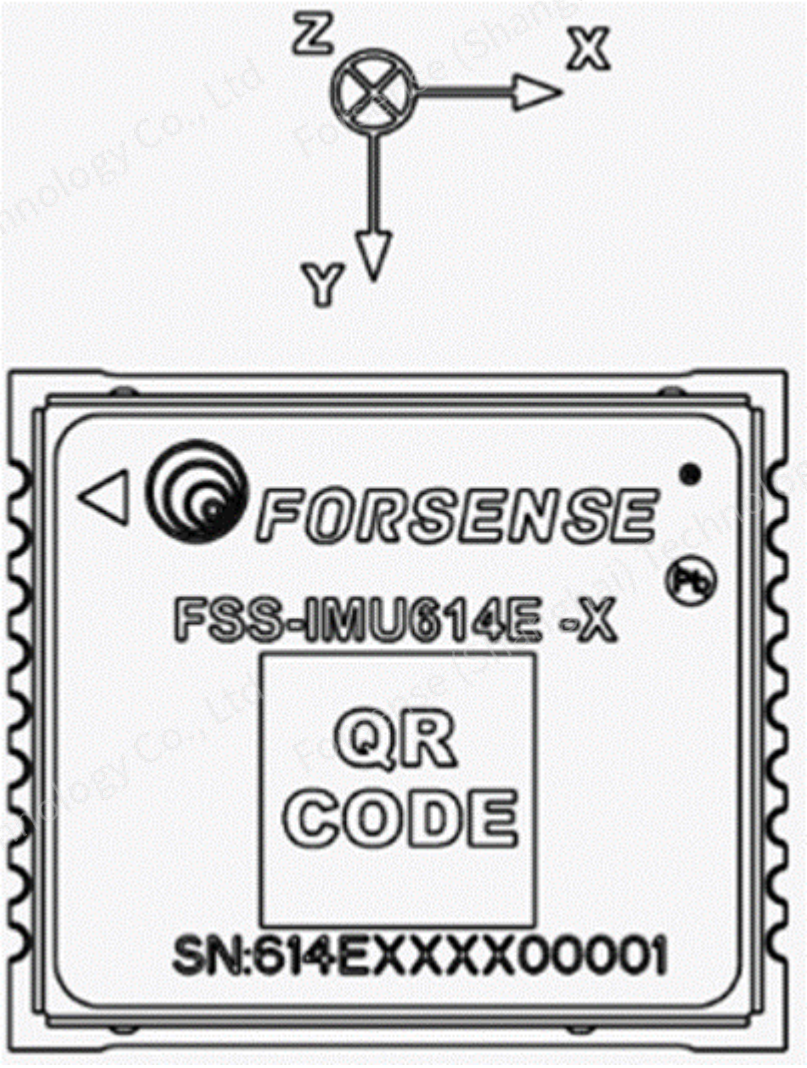
7. Communication Protocol

Reference Documents: Forsense IMU Communication Protocols（en）

Includes Serial Port/SPI/CAN communication protocols, coordinate system settings, filter settings, Parameter settings, OTA update methods, time synchronization, etc.

8. Coordinate System Definition

Figure7 Coordinate System Definition



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

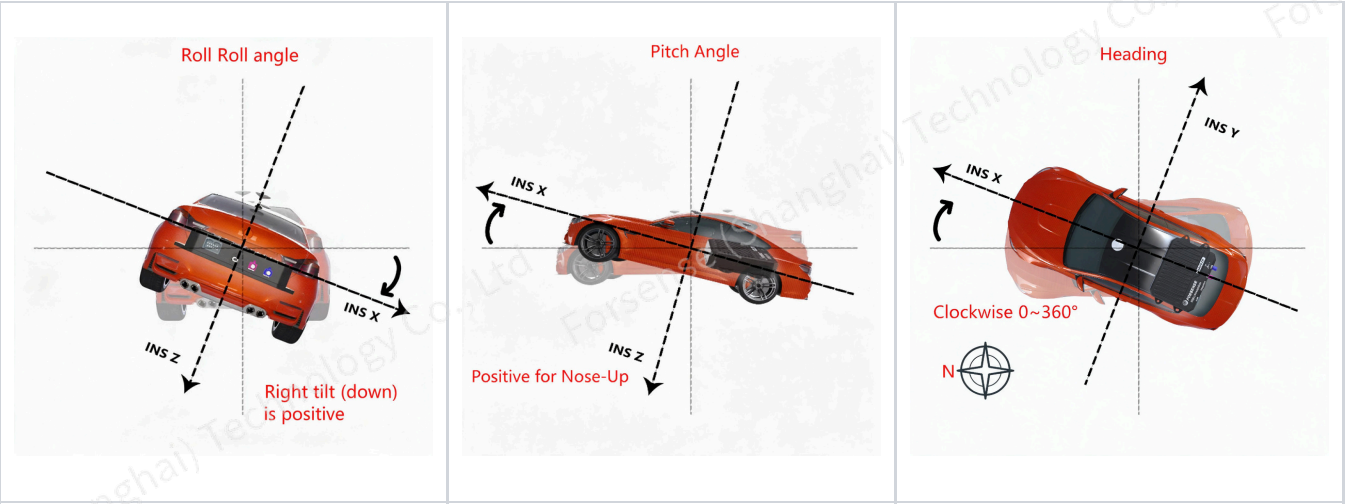
Rotation about the Z-axis: Yaw angle Yaw Range: 0° ~ 360°

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 8 Roll, Pitch, Yaw angle Schematic



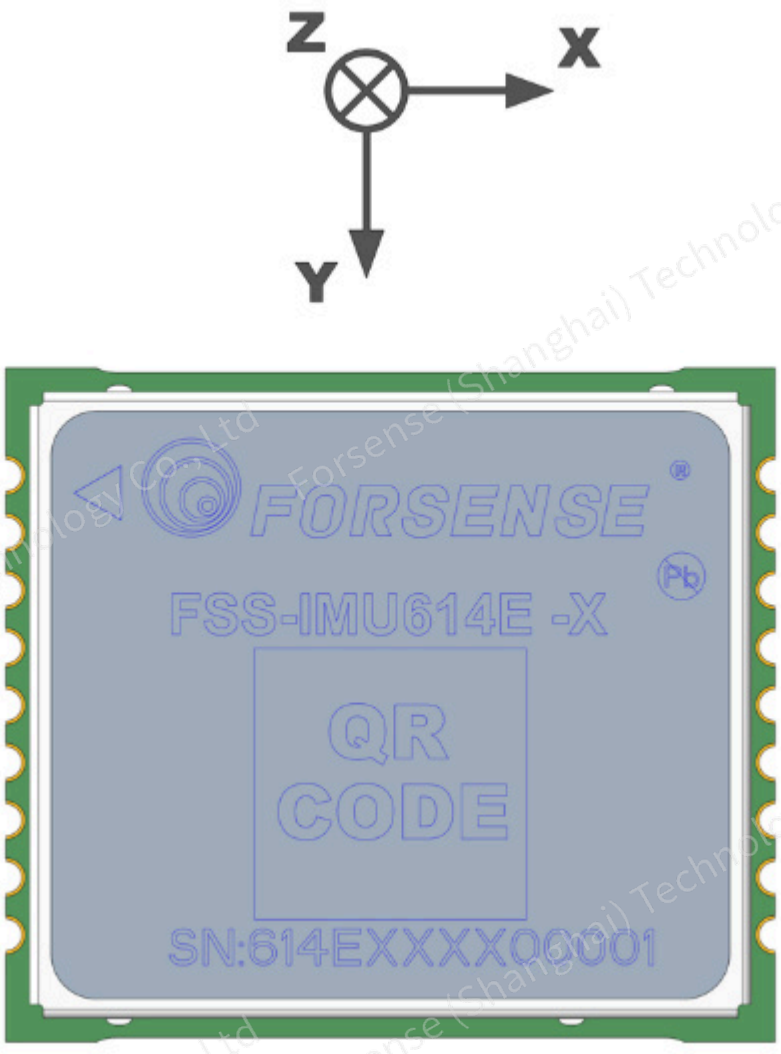
9. Usage Examples

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 installation orientation should be consistent with the vehicle's forward direction.

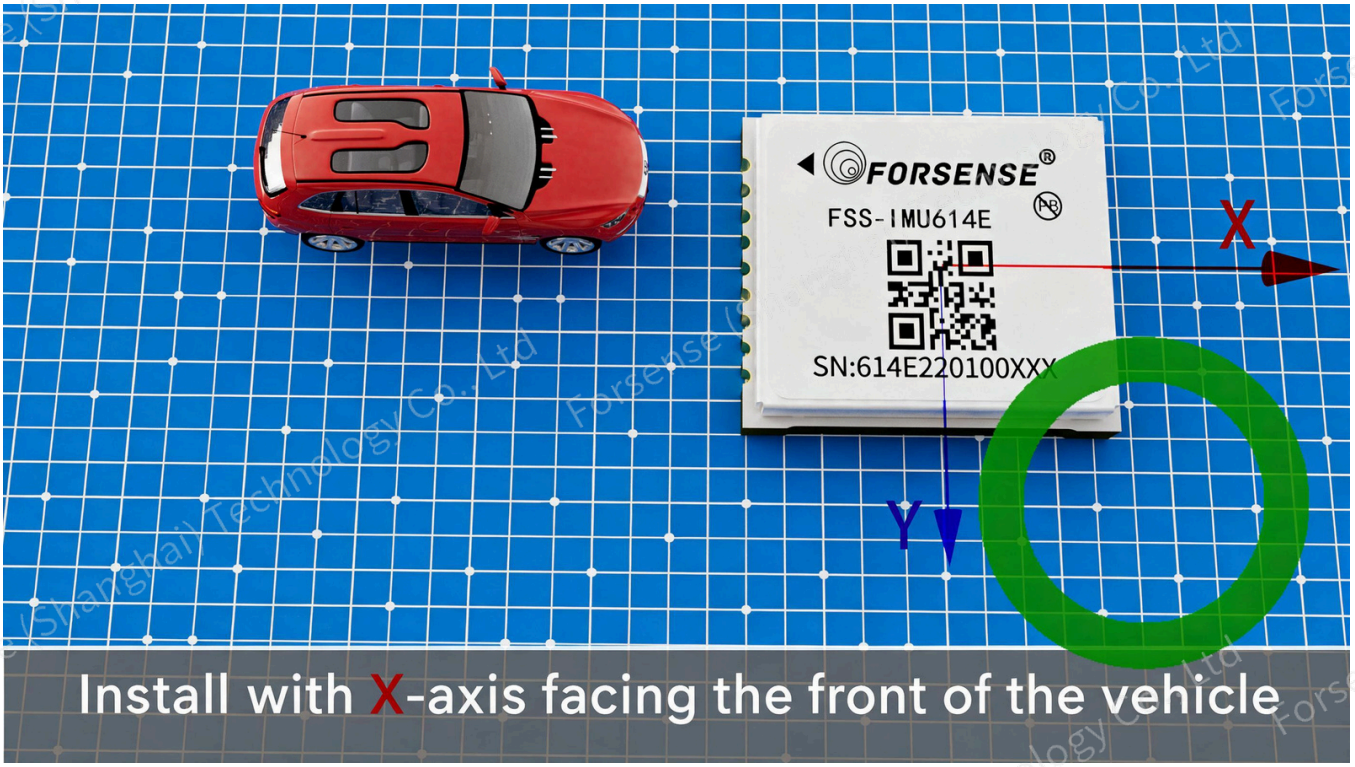
Figure 9 Module Installation Diagram



The correct installation diagram is shown below

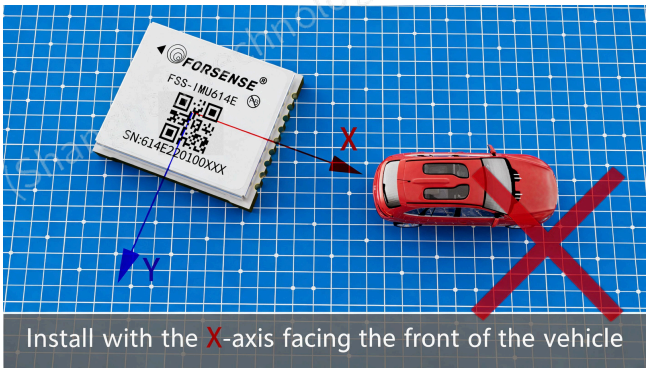
X-axis points toward the front of the vehicle

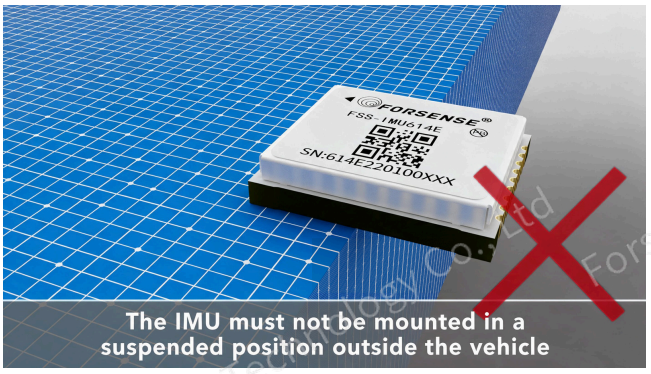
Figure 10 Correct Installation Diagram



The following installation methods are all incorrect.

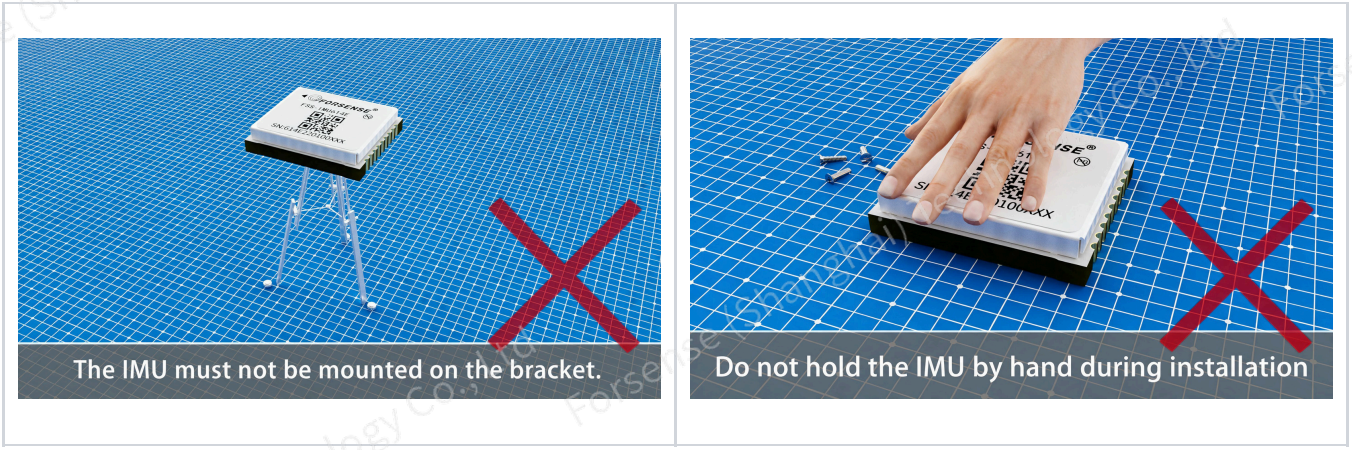
Figure 11 Incorrect Installation Diagram







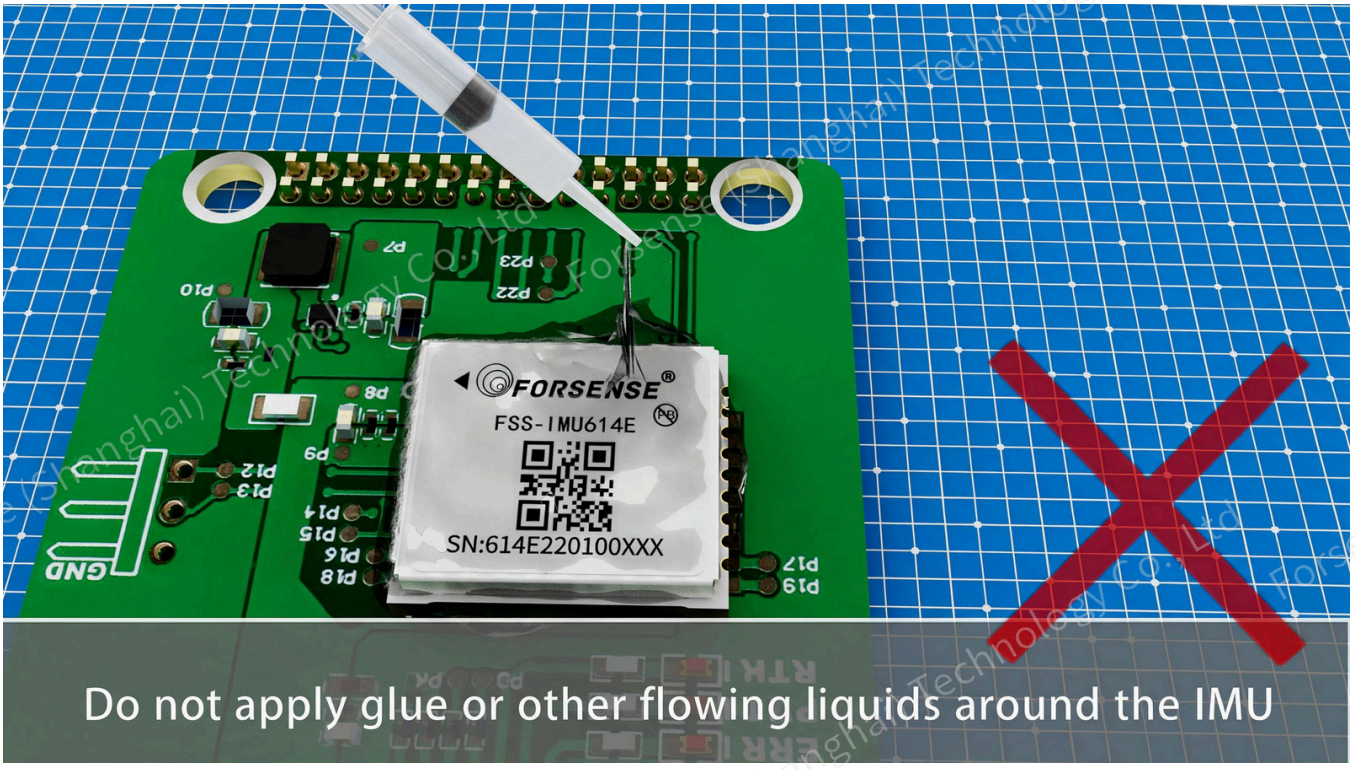




3. IMU Installation Precautions

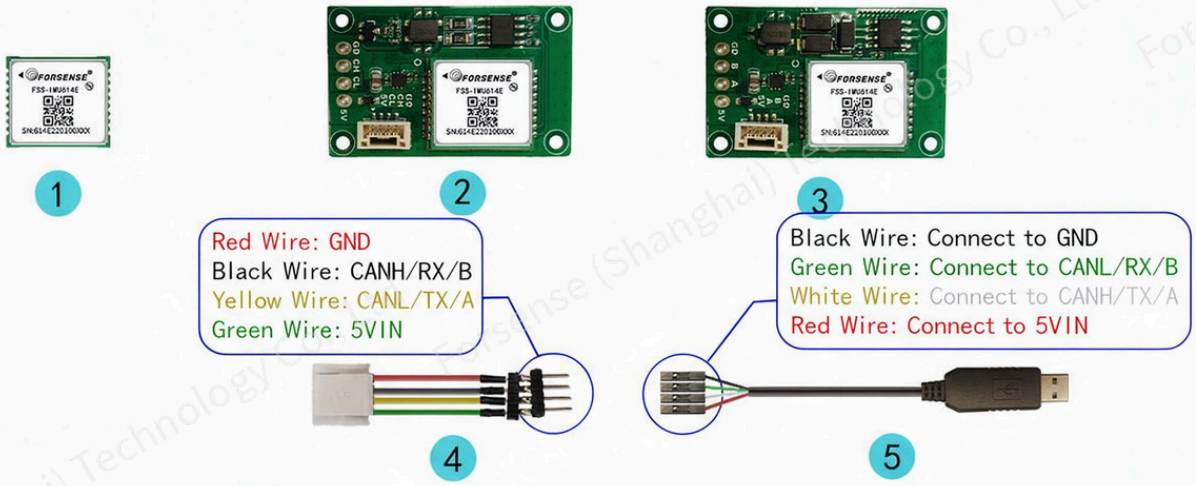
Do not apply adhesive or other flowing liquids around the IMU to prevent liquid from seeping into the IMU interior through gaps and affecting its performance.

Figure 12 Incorrect Installation Diagram



9.2 Connection PC software Example

Figure 13 Module Connection PC software Diagram



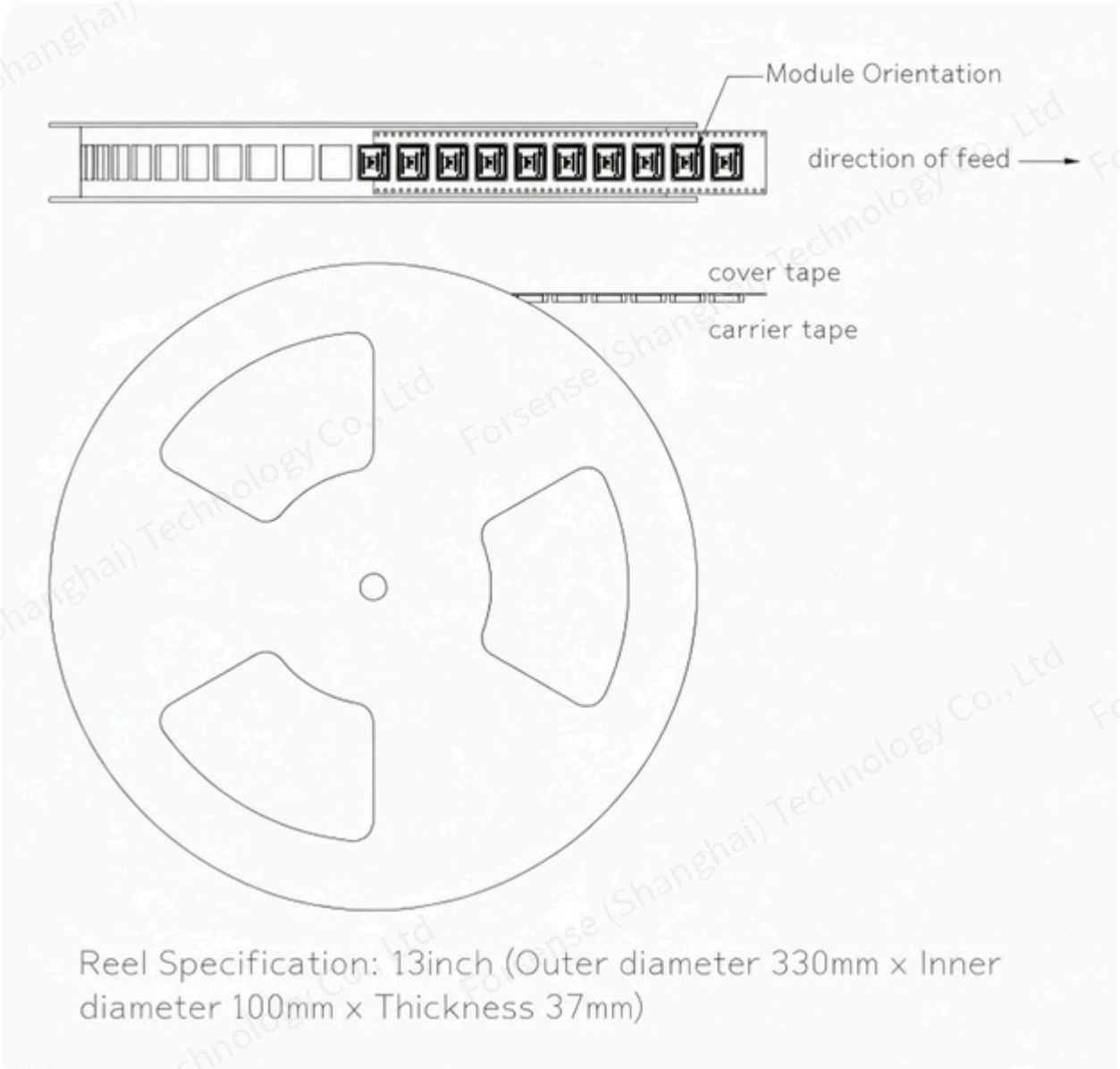
	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	SMD CAN Version Test Base Plate	1 pc
3	SMD 485 Version Test Base Plate	1 pc
4	4-PIN Connector	1 pc
5	TTL Serial Port Cable	1 pc

10. Packaging

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

10.1 Tape-and-Reel Packaging

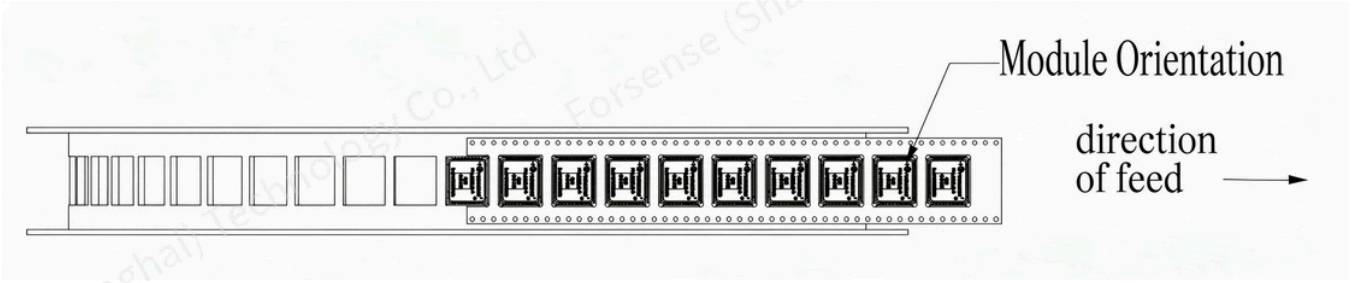
Figure14Tape and Reel Packaging Diagram



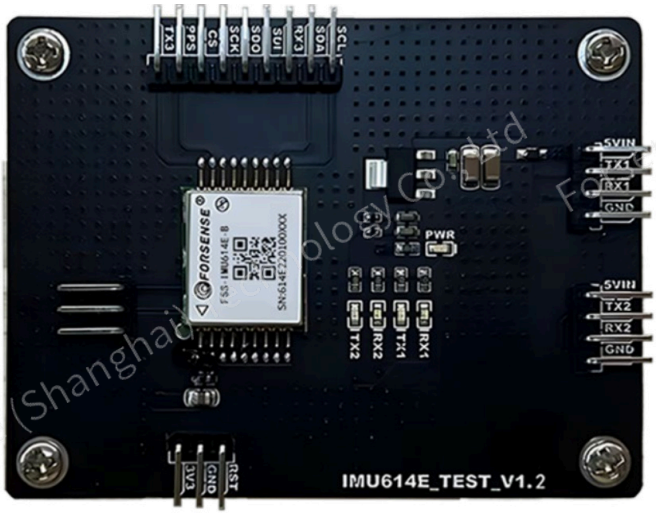
10.2 carrier tape

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

Figure15 Module Position and Orientation at carrier tape



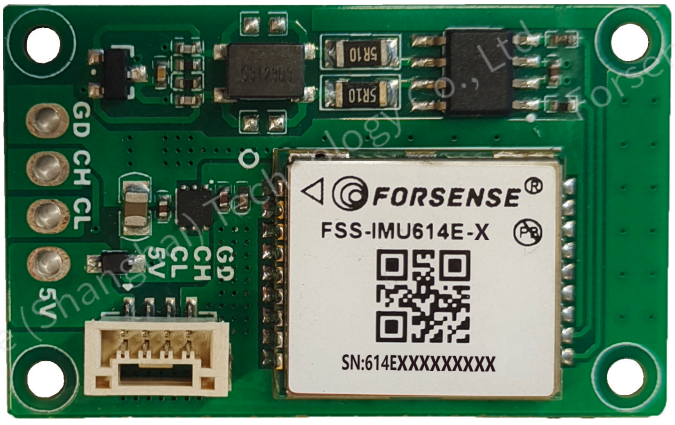
11. OptionalAccessories



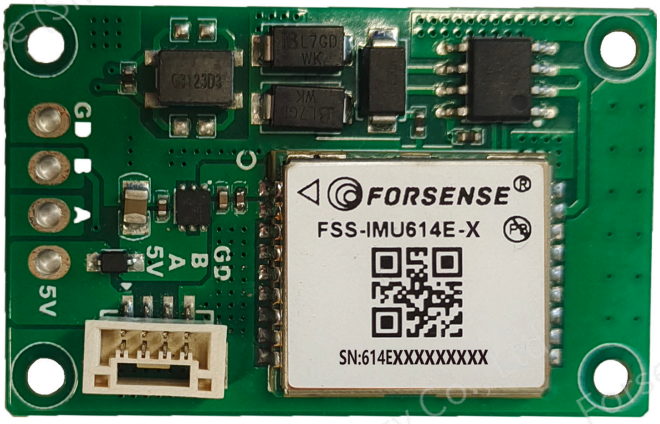
IMU614E-X Base Plate Test



TTL Serial Port Cable



IMU614E Series SMD CAN Version Base Plate Test



IMU614E Series SMD RS-485 Version Base Plate Test



USB to CAN Module

12. UpdateRecord

Latest Manual Version: IMU614E-Q_Datasheet_Product Manual(en)

Version	Date	Status/Notes
Version 1.0	2023.11.10	Initial Release
Version 1.1	2023.12.01	Updated Command Mode
Version 1.2	2023.12.14	Added Accessories
Version 1.3	2024.02.04	Updated Electrical Characteristics
Version 1.4	2024.02.27	Updated Reflow Soldering Profile and ESD Protection Guidelines
Version 1.5	2024.03.26	Updated Pin Definition
Version 1.6	2025.01.23	Adjusted table numbers, figure numbers, and section numbers
Version 1.7	2025.06.12	Added IMU phase center diagram
Version 1.8	2025.08.01	Simplified communication protocol
Version 1.9	2025.09.26	Added ESD protection level
Version 1.10	2025.12.03	Updated Dimensional Drawing
Version 1.11	2025.12.24	Removed TTL Test Base Plate
Version 1.12	2026.2.10	Updated "SMD CAN Version IMU614E Series Test Base Plate","SMD RS-485 Version IMU614E Series Test Base Plate", "Recommended Pad Size"