FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-B

Product manual



Forsense (Shanghai) Technology Co., Ltd

Please read this user manual carefully before using this product.

FORSENSE
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Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-B-Product Manual(en)

Features

Tactical-Grade MEMS Gyroscope

- 2.5°/hr Bias instability
- XY:0.4 °/√hr ,Z:0.3 °/√hr Angle Random Walk
- 0.015°/s Temperature Drift (-40℃~85℃, ≤1℃/min @1σ)

Tactical-grade MEMS Accelerometer

- 25μg Bias instability
- 0.04m/s /√hr Velocity Random Walk
- XY: 0.5mg,Z:2mg Temperature Drift (-40℃~85℃, ≤1℃/min @1σ)

Wide-range refined temperature compensation

- -40°C to 85°C temperature compensation
- Fine-grained temperature calibration

independent rotary table calibration

- Independent calibration of sensitivity for each module Bias Misalignment

High-intensity operating condition tolerance

- Ultra-high shock resistance: 2000g (0.5ms half-sine, 3-axis)
- Superior 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 Interfaces, Compact Size

- Configurable Output Sampling Rate up to 1KHz
- Supports Serial Port, I2C, SPI, CAN and Multiple Interfaces
- 14.7*17*3.3mm, Weight Only 2g

Product Overview

IMU614E-B is a 6 degrees of freedom (DOF) MEMS inertial sensor module developed by Forsense Technology. It comes standard with tri-axis Gyroscope and acceleration output.

High precision and high resolution enable the detection of subtle vibrations and tilts. The wide-range output allows for motion sensing under large dynamic conditions. All modules undergo fine-grained temperature compensation and independent calibration across an ultra-wide temperature range before shipment, ensuring stable performance under extreme operating conditions while maintaining high consistency in product performance.

Application Fields

- Autonomous Driving: Vehicle-mounted,Inspection Vehicles, Engineering Vehicles, Underwater
- Precision Measurement: Downhole, Tunnel, Vibration, Tilt
- Stabilized Platform: Pan tilt, Satellite Communication on the Move (Satcom on the Move), UAV
- Automatic Control: Large Industrial Equipment, Automation System

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!

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1. Performance Parameter

1.1 Key Metrics of Gyroscope

Table 1 Key Metrics of Gyroscope

Parameter	Test Conditions/Notes	Typical Value	Unit
Measurement Range		±500	°/s
Bias instability[1]	@25℃, Allan Variance, 1σ	2.5	°/hr
Bias stability	GJB, 10s Smoothing	7	°/hr
Bias Repeatability	GJB	7	°/hr
Resolution		0.0076	°/s
Misalignment between axes		0.02	°
g-value Sensitivity		10.2604	°/h/g
Internal low-pass cutoff frequency(Bandwidth)	Software Adjustable	116	Hz
ODR		1000	Hz
measure delay		3	ms
Bias over temperature[2]	-40℃ ~ 85℃, ≤1℃/min @1σ	0.015	°/s
Random Walk X-axis[1]	@25℃, Allan Variance, 1σ	0.4	°/√hr
Random Walk Y-axis		0.4	°/√hr
Random Walk Z-axis		0.3	°/√hr
scale coefficient error		2.5	‰
scale factor nonlinear		100	ppm

Note 1: IEEE standard, provided by the Allan Variance curve at a static temperature of 25°C

Note2: The 1σ variation of Bias across the full temperature range at a heating rate of 1°C/min

1.2 Accelerometer Key Metrics

Table 2 Accelerometer Key Metrics

Parameter	Test Conditions/Remarks	Typical Value	Unit
Measurement Range		±6	g
Bias instability[1]	@25℃, Allan Variance, 1σ	25	μg
Bias stability	GJB, 10s Smoothing	55	μg
Bias Repeatability	GJB	0.2	mg
Resolution		0.0916	mg
Misalignment between axes		0.02	°
Internal low-pass cutoff frequency (Bandwidth)	Software Adjustable	116	Hz
ODR		1000	Hz
measure delay		3	ms
Bias over temperature[2]	-40℃ ~ 85℃, ≤1℃/min @1σ	XY: 0.5 Z: 2	mg
Random Walk[1]	@25℃, Allan Variance, 1σ	0.04	m/s/√hr
scale coefficient error		0.5	‰
scale factor nonlinear		200	ppm

Note 1: IEEE standard, given by the Allan variance curve under static conditions at 25°C.

Note2: 1σ value of full-temperature Bias variation at a heating rate of 1°C/min

Figure 1 Gyroscope Allan Variance Typical Curve

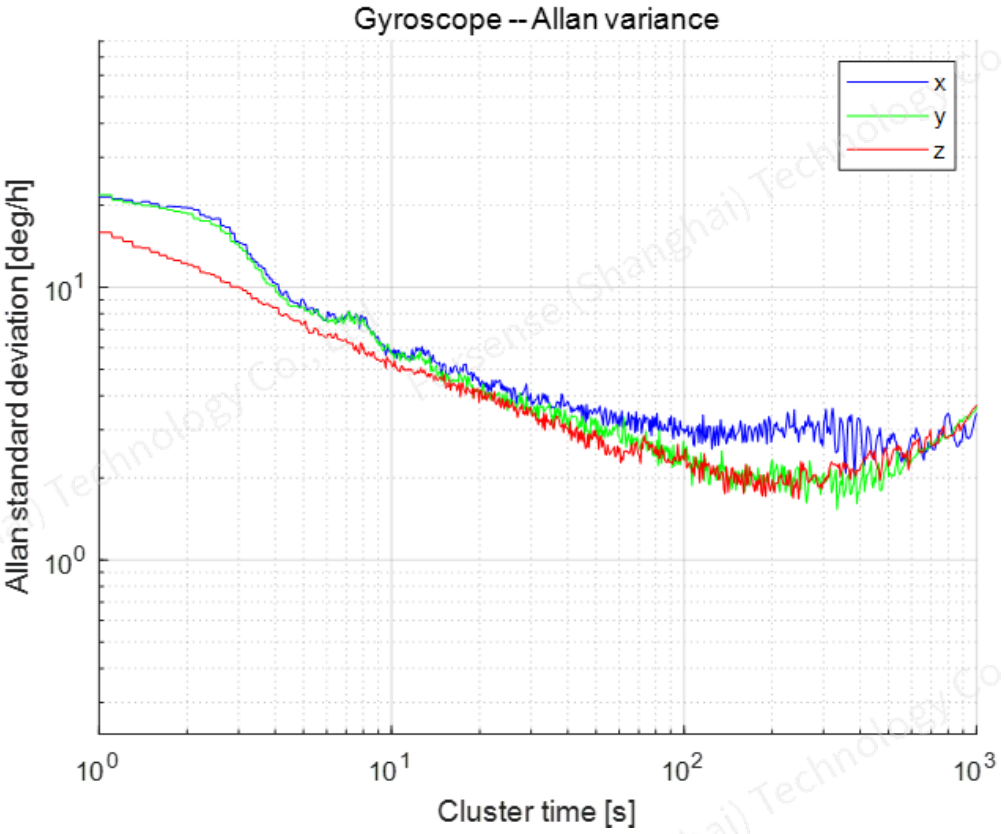
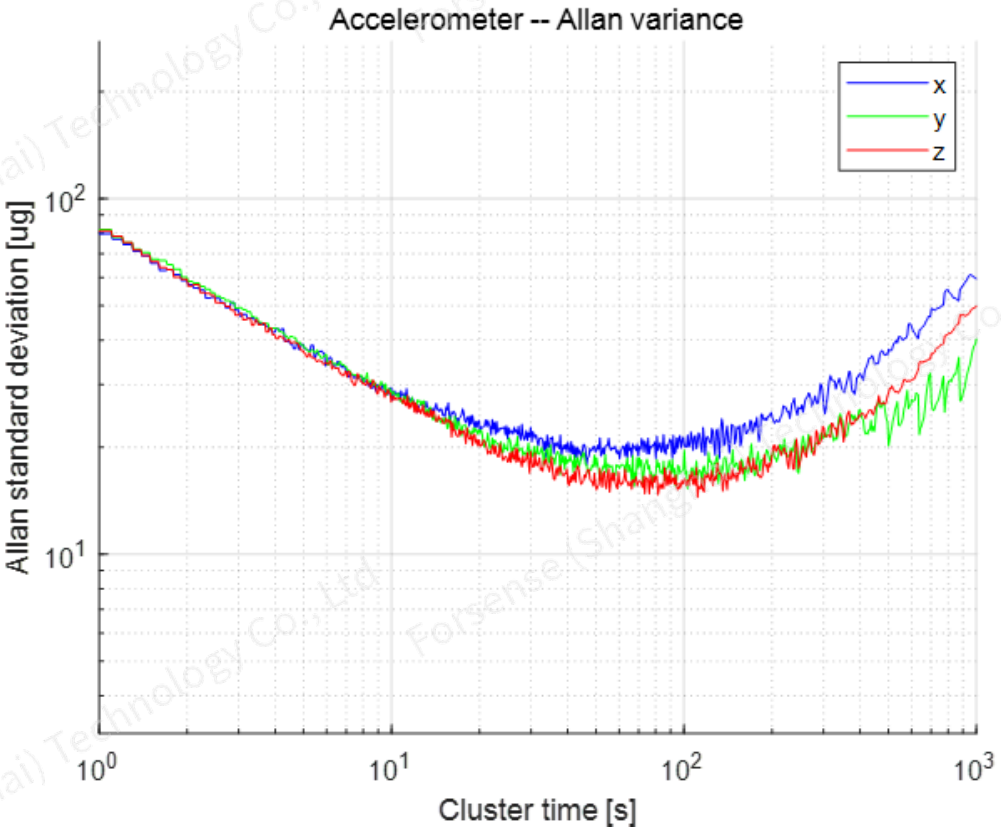


Figure 2 Accelerometer Allan Variance Typical Curve



2. Physical Structure

Figure 3 Outline Structure andRecommended PadDimensions (Unit: mm)

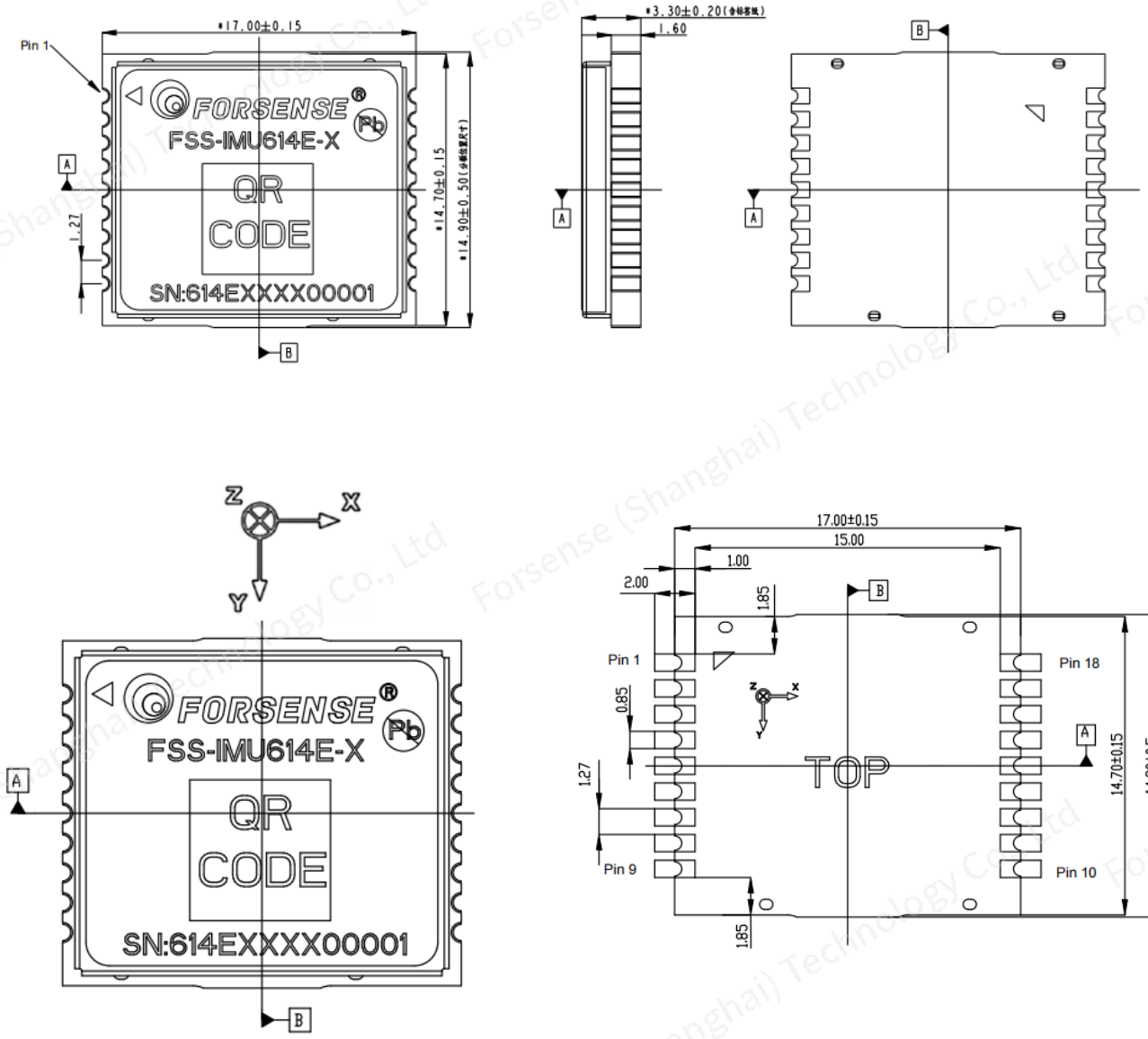
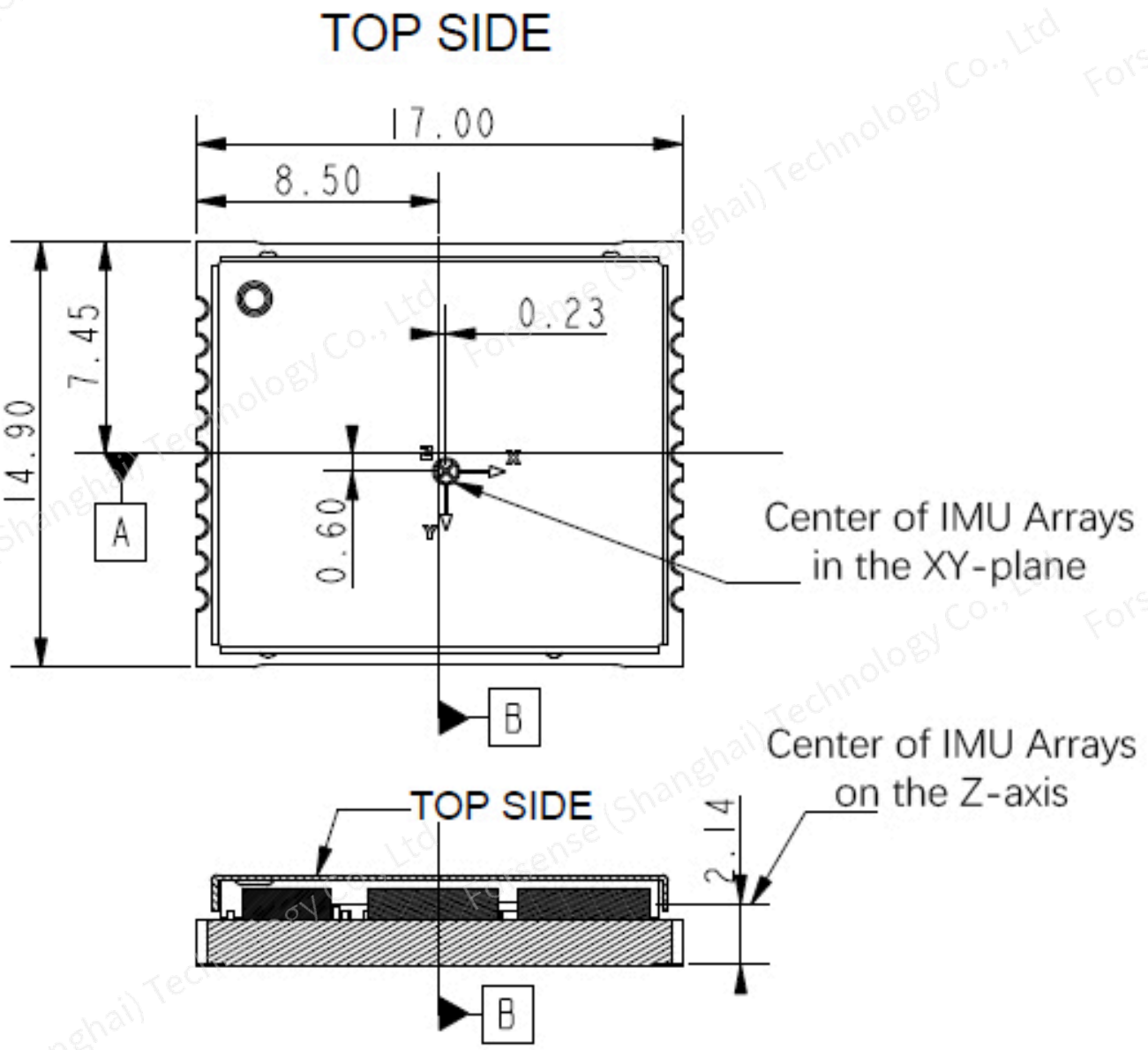


Figure 4 IMU Measurement Center (Unit: mm)


TOP SIDE
17.00
8.50
14.90
7.45
0.23
0.60
A
B
Center of IMU Arrays
in the XY-plane
TOP SIDE
2.14
Center of IMU Arrays
on the Z-axis
B

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		0.3		W
Operating Temperature (Tot)	Tot	-40		85	℃
Storage Temperature (Tstg)	Tstg	-40		85	℃

3.3 IO Threshold Characteristics

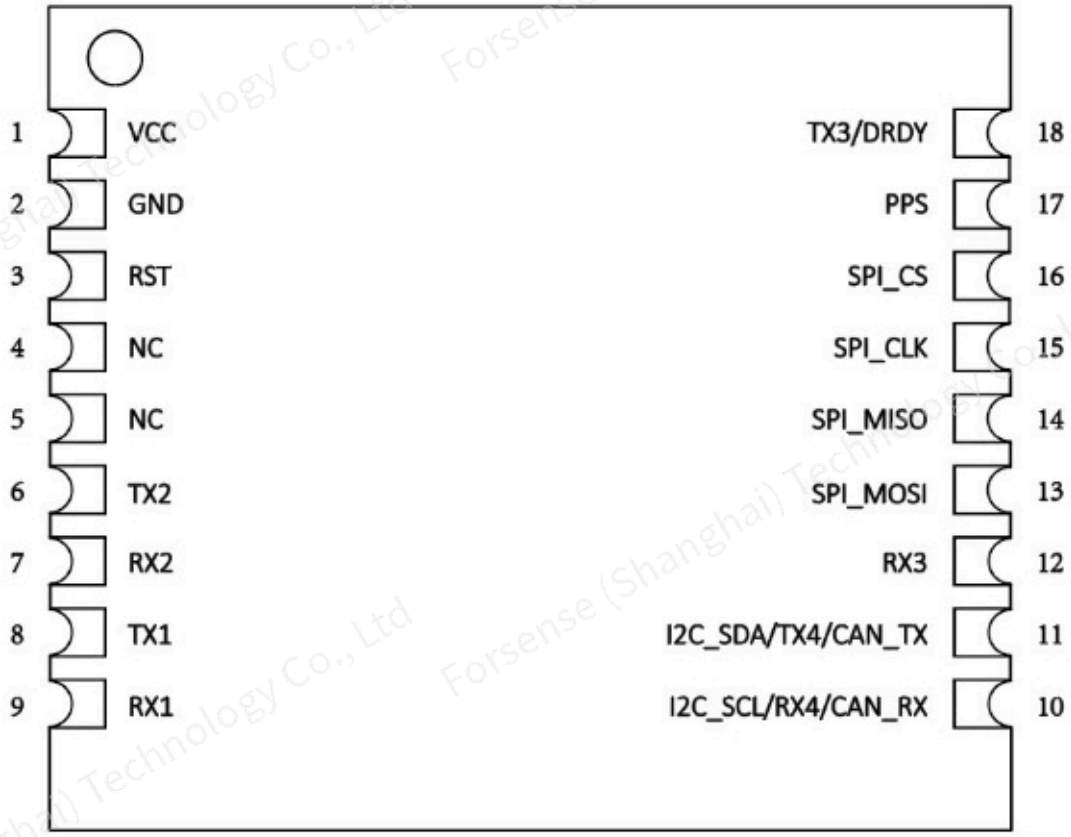
Table 5 IO Threshold Characteristics

Parameter	Symbol	Min	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

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4. Pin Definition

Figure5 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 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	Receive asynchronous data Output / Can Be Used 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 Soldering Oven Temperature Profile

Figure 6 Soldering Oven Temperature Profile

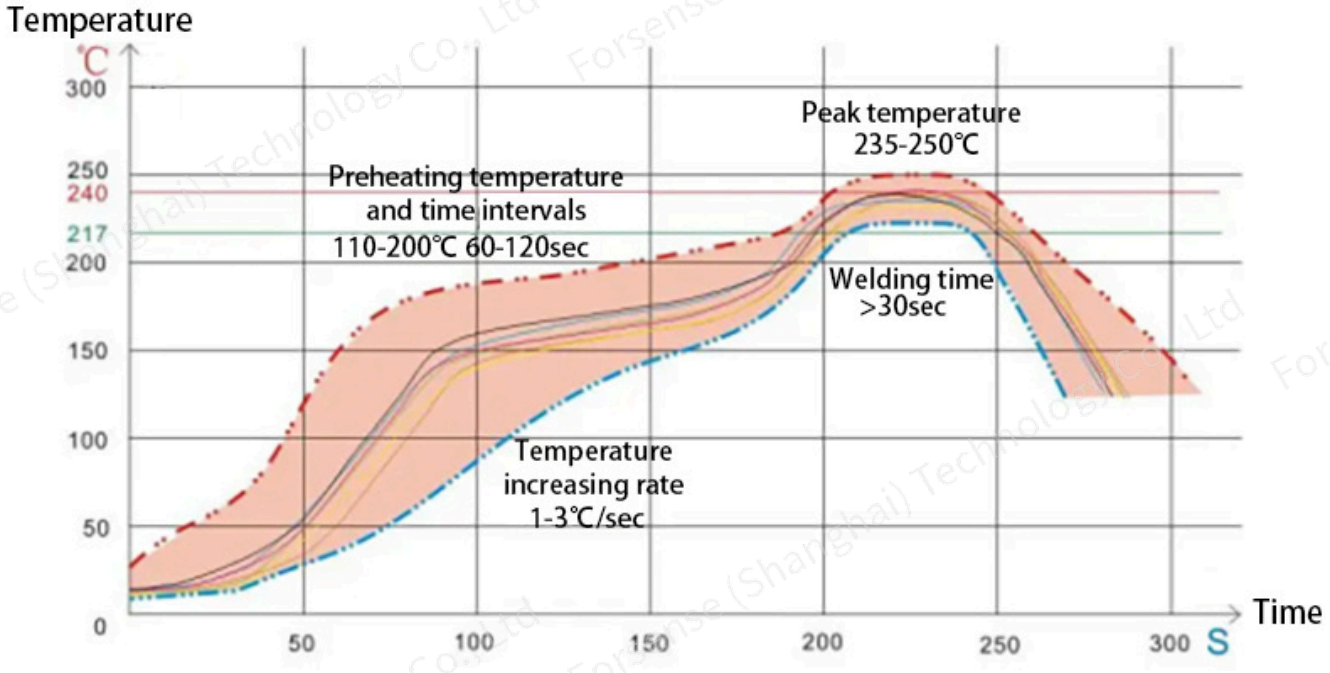


Table 7 Temperature Setting Mode

Item	Lower Limit	Upper Limit	Unit
Maximum Temperature Ramp Rate (Target = 0.8) (Time interval for slope calculation = 60 s)	1	3	°/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
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 solder reflow, 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 defects.
- Due to sensitive components inside the module, the maximum temperature of the customer's reflow oven must not exceed 260°C (measured as the package top surface temperature).
- 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 negative 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, in accordance with IPC-A-610F standards.
- **When soldering with an electric iron, control the temperature between 260°C and 290°C, limit single soldering time to no more than 3 s, and implement proper ESD protection;**

6. ESD Protection

Figure 7 ESD Protection



Static electricity can cause 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 particularly important. Production and transportation processes must strictly follow electrostatic protection procedures and adhere 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 good grounding wires (cordless anti-static wrist straps are not allowed; wearing anti-static gloves is recommended).
- Packaging and PCBs must be made of qualified anti-static materials.

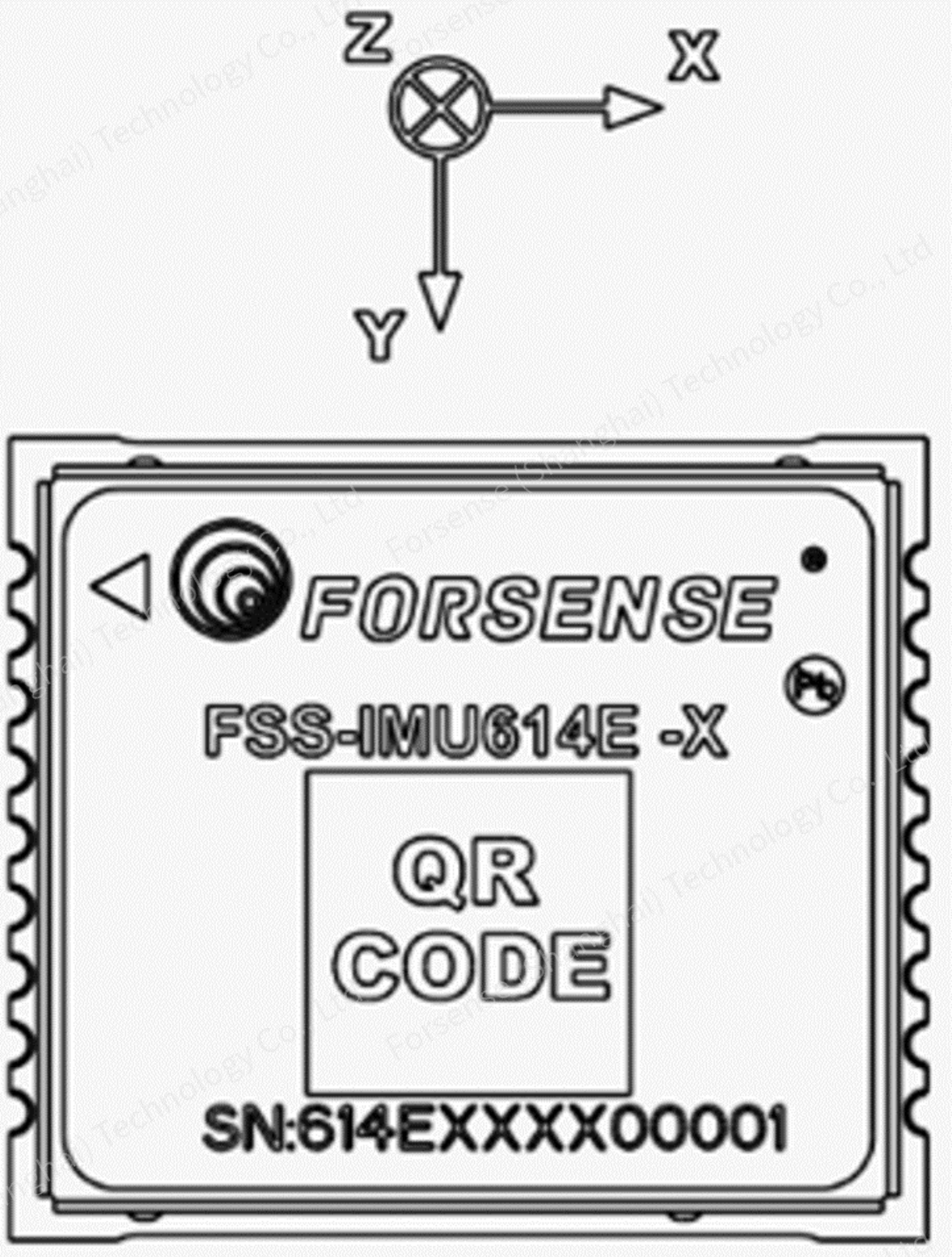
7. Communication Protocol

Reference Document: Forsense IMU Communication Protocols（en）

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

8. Coordinate System Definition

Figure8 Coordinate System Definition



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

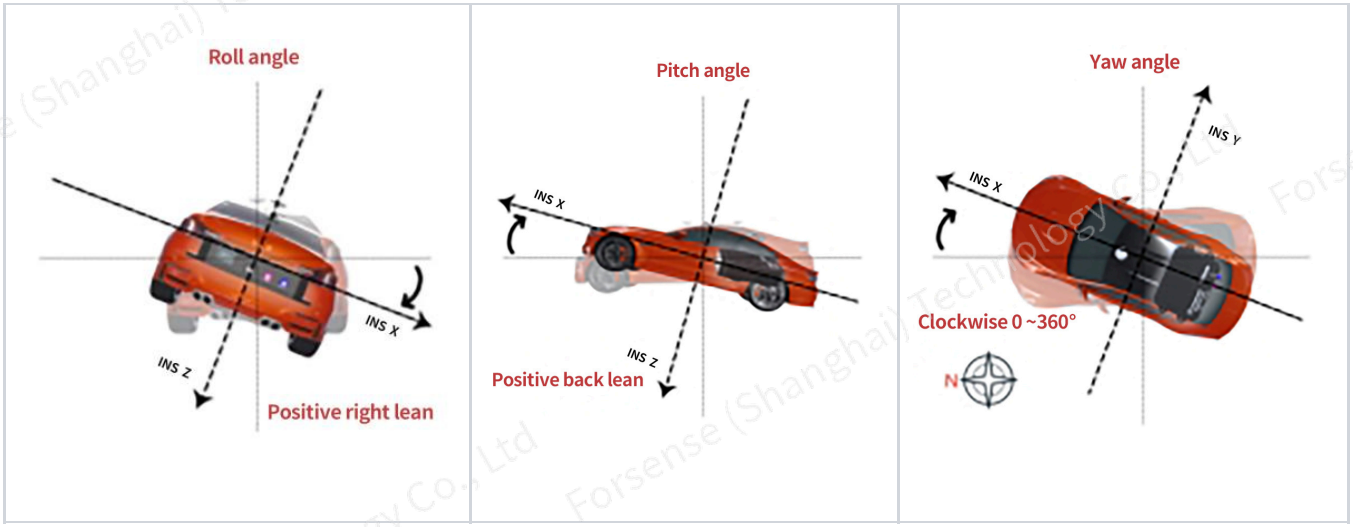
Rotation about the Z-axis: Yaw angle Yaw range: 0° ~ 360°;

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 9 Schematic of Roll, Pitch, and Yaw angle



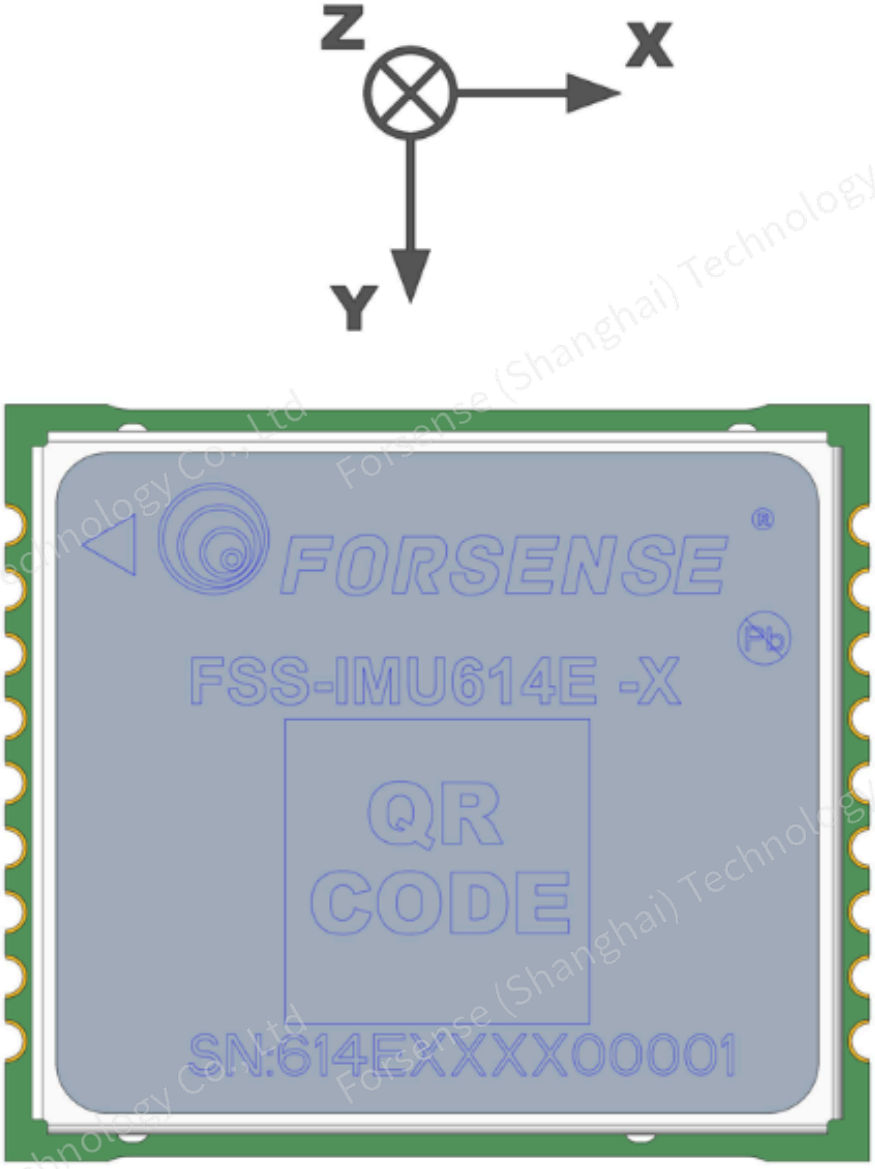
9. Usage Examples

9.1 Device Installation

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

2. The orientation of the installed module must align with the direction of the vehicle's front.

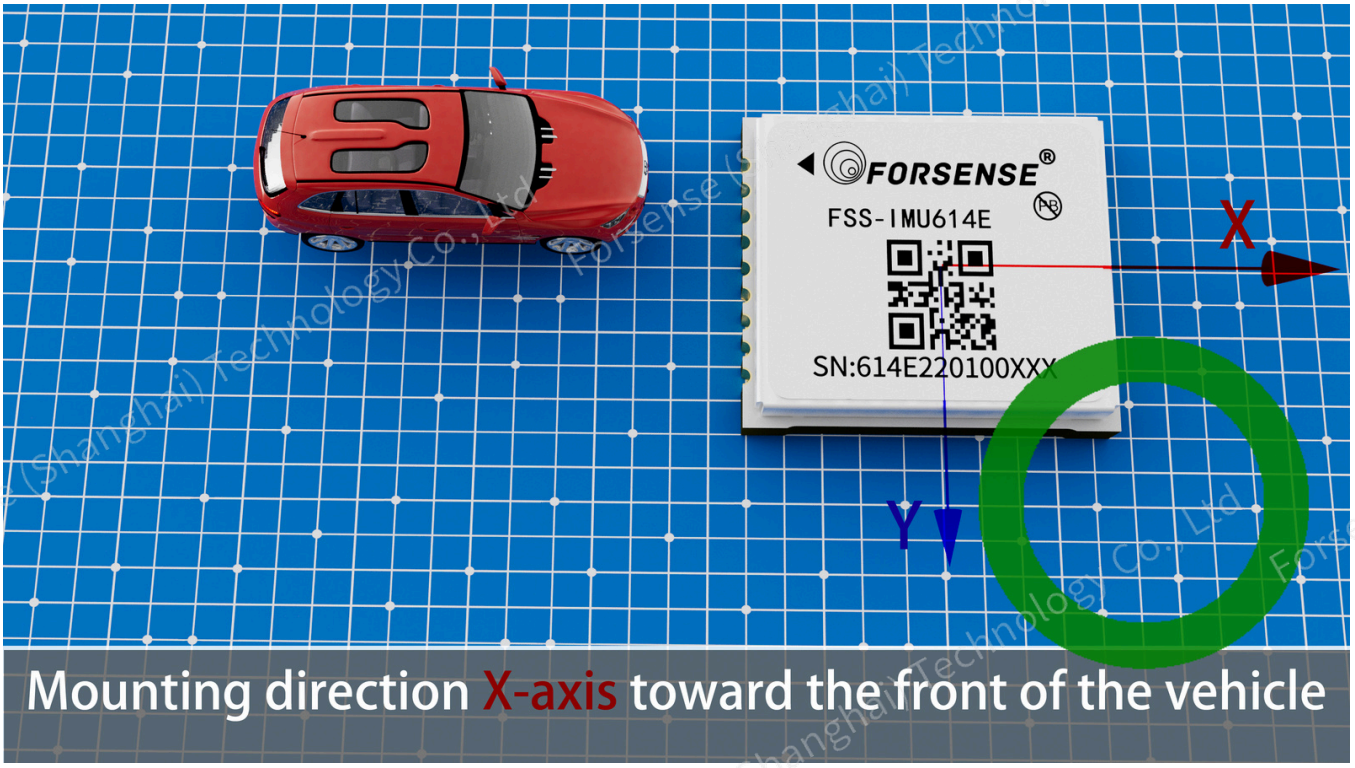
Figure10 Module Installation Diagram



The correct installation diagram is shown below

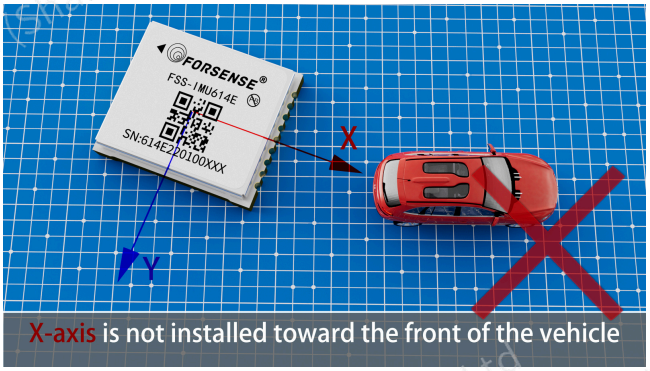
X-axis points toward the front of the vehicle

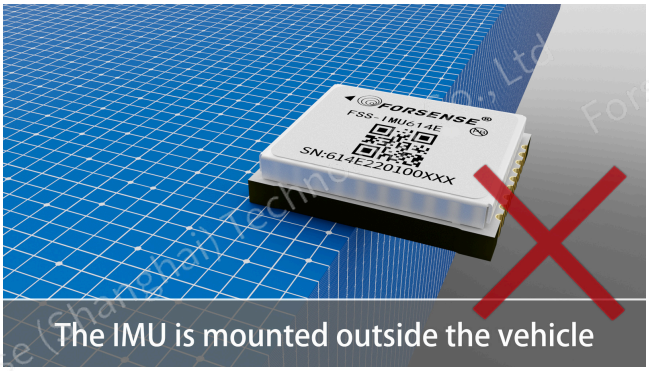
Figure 11 Correct Installation Diagram

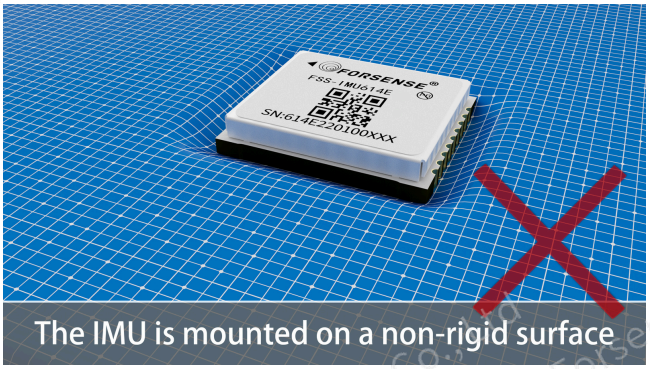


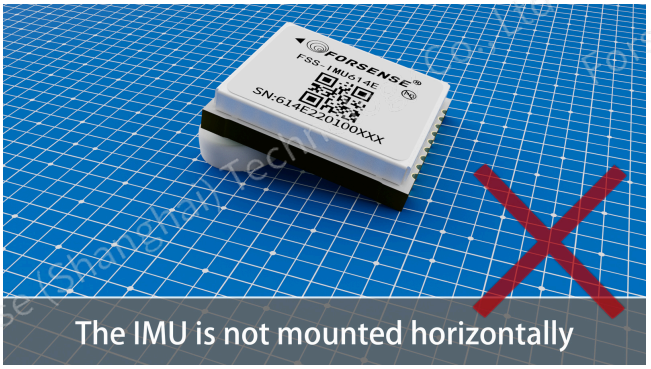
The following installation methods are all incorrect

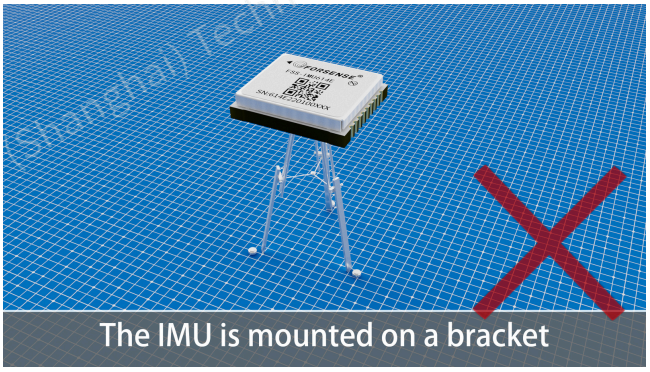
Figure12 Incorrect Installation Diagram









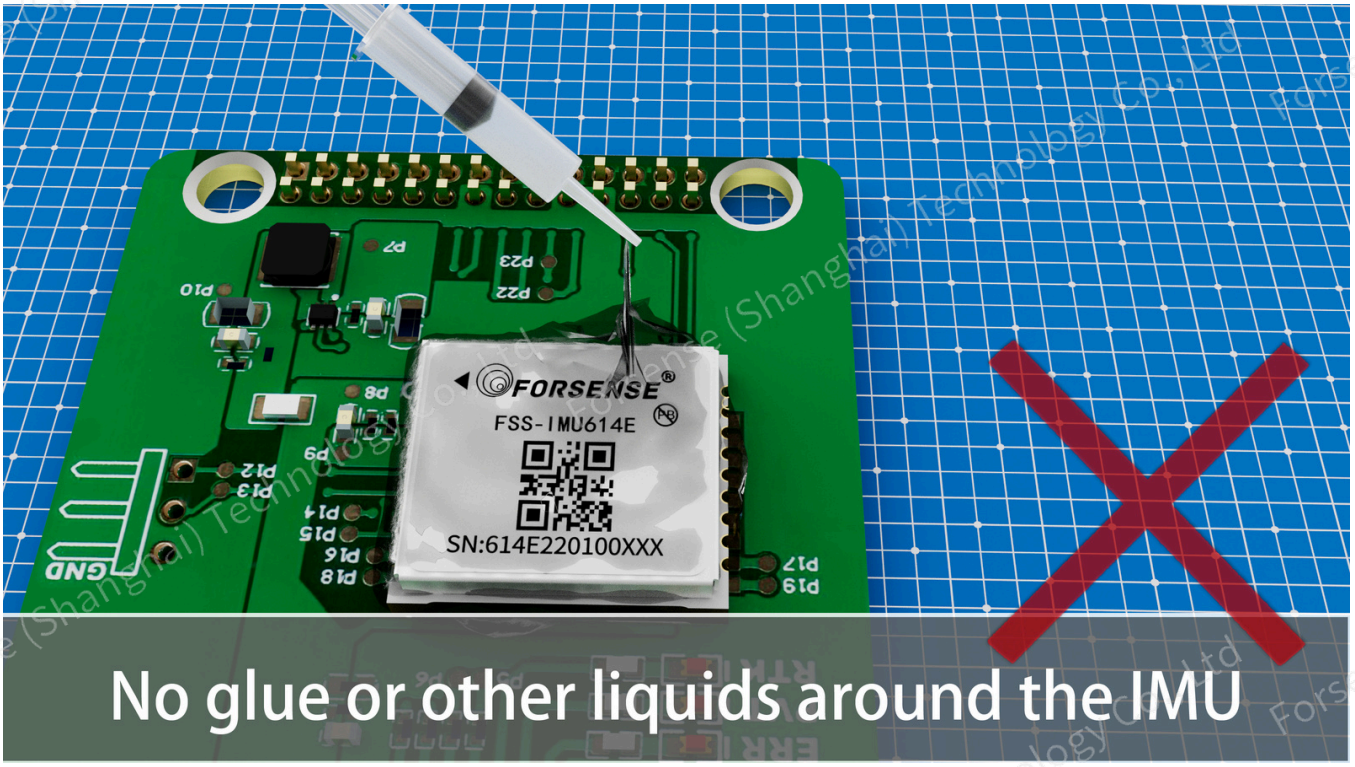




3. IMU Installation Precautions

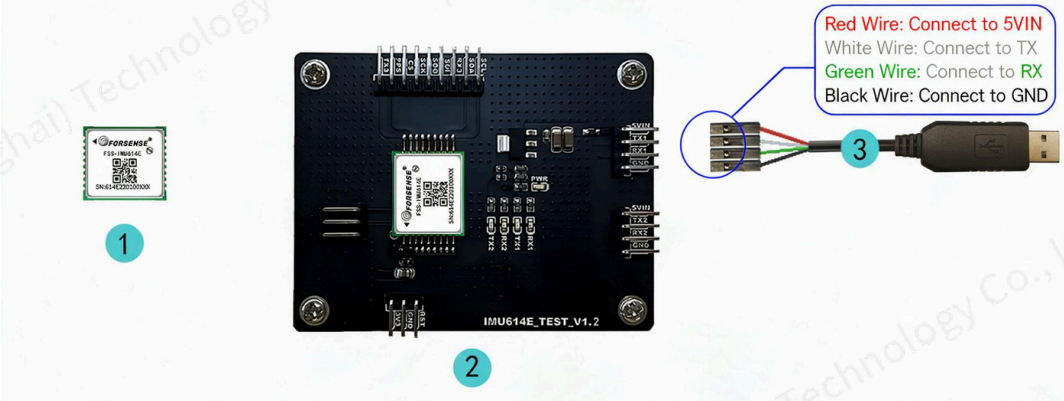
Do not apply adhesive or other flowing liquids around the IMU to prevent liquid from seeping into the IMU through gaps and affecting its performance.

Figure 13 Incorrect Installation Diagram



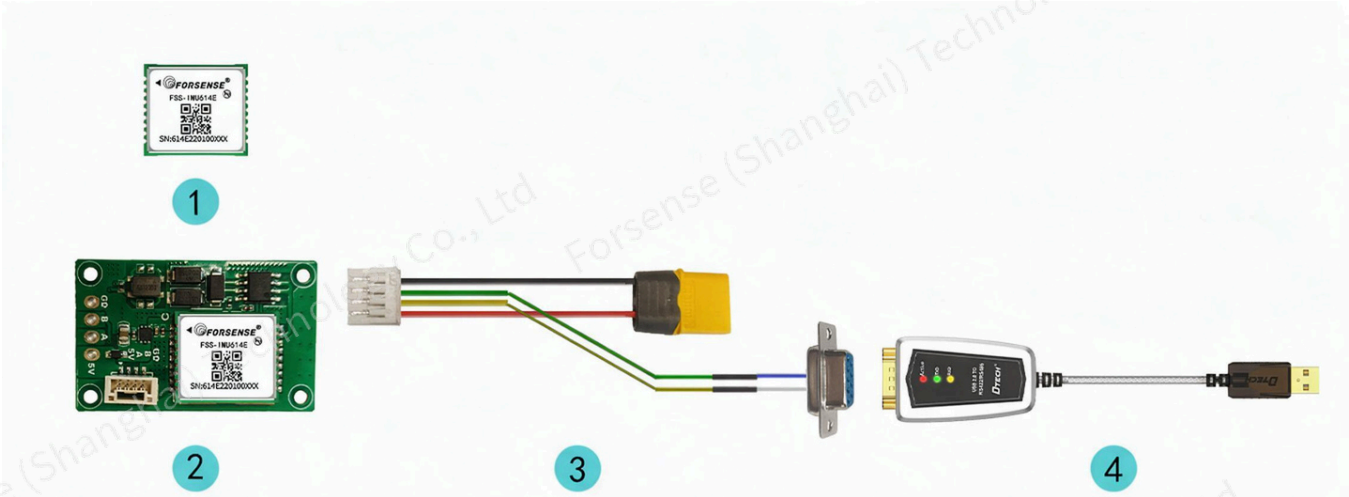
9.2 Test Base Plate Connection Example

Figure 14New Test Base Plate Connection Diagram for 614E Module



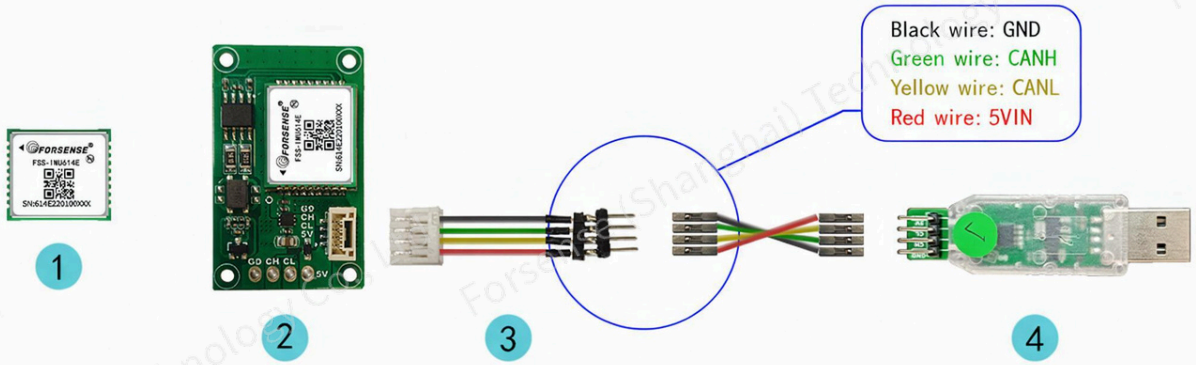
Name		Quantity
1	IMU614E Series Module	1 pc
Accessory Name		**Quantity**
2	IMU614E New Version Test Base Plate	1 pc
3	TTL Serial Port Cable	1 pc

Figure 15 614E RS485 VersionSMD TypeTest Base Plate



	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	RS485 Version Test Base Plate	1 pc
3	RS485 Test Base Plate Test Harness	1 pc
4	RS485 to USB Adapter Cable	1 pc

Figure 16 614E CAN VersionSMD TypeTest Base Plate



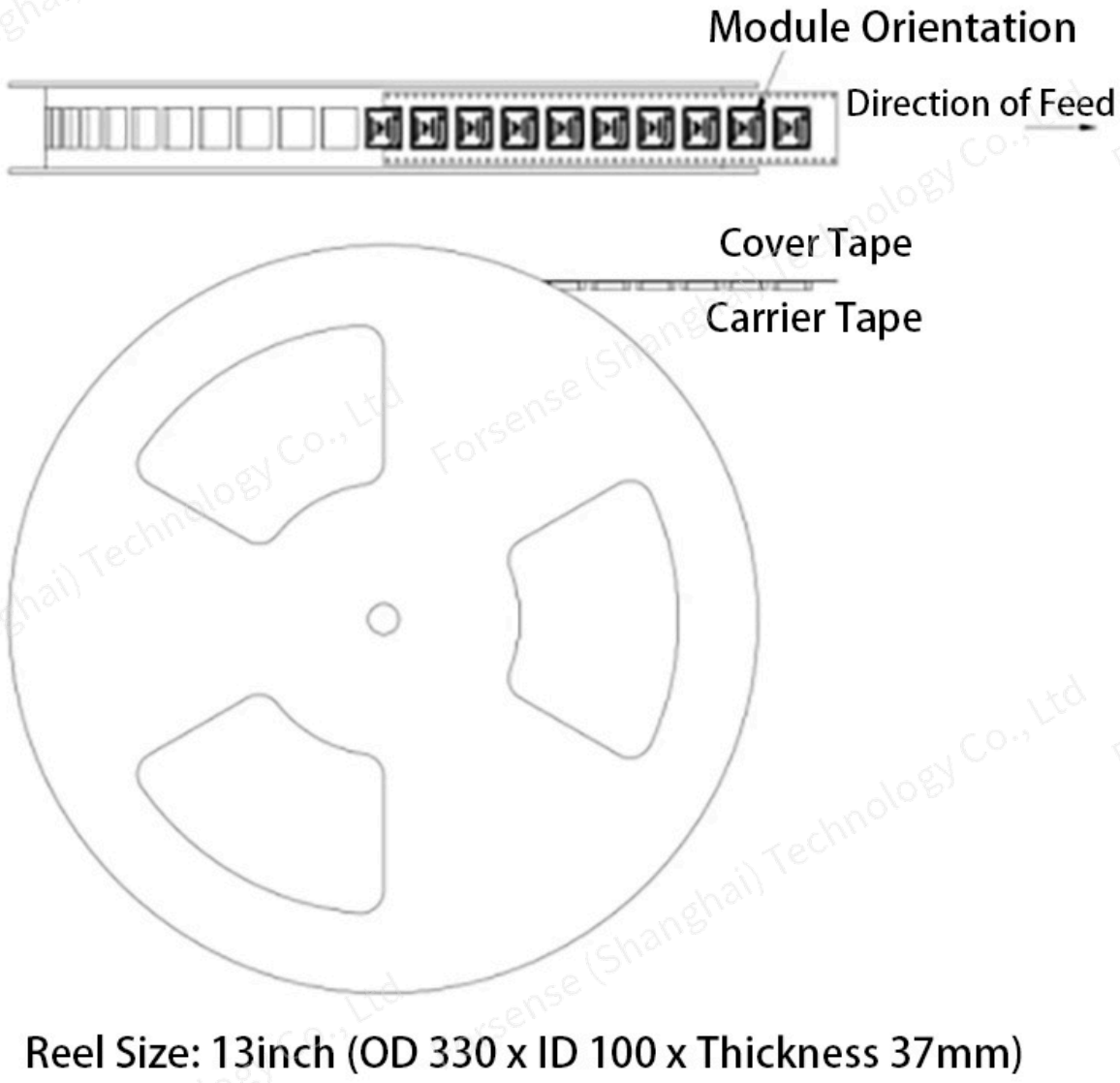
	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	CAN Version Test Base Plate	1 pc
3	4-PIN Connector	1 pc
4	TTL Serial Port Cable	1 pc

10. Packaging

The IMU614E-B module uses tape-and-reel sealed packaging to meet high-efficiency production requirements.

10.1 Tape-and-Reel Packaging

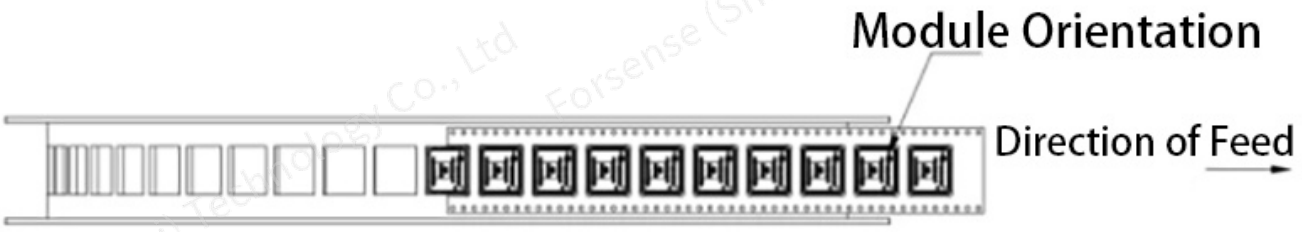
Figure18 Tape Reel Packaging Diagram



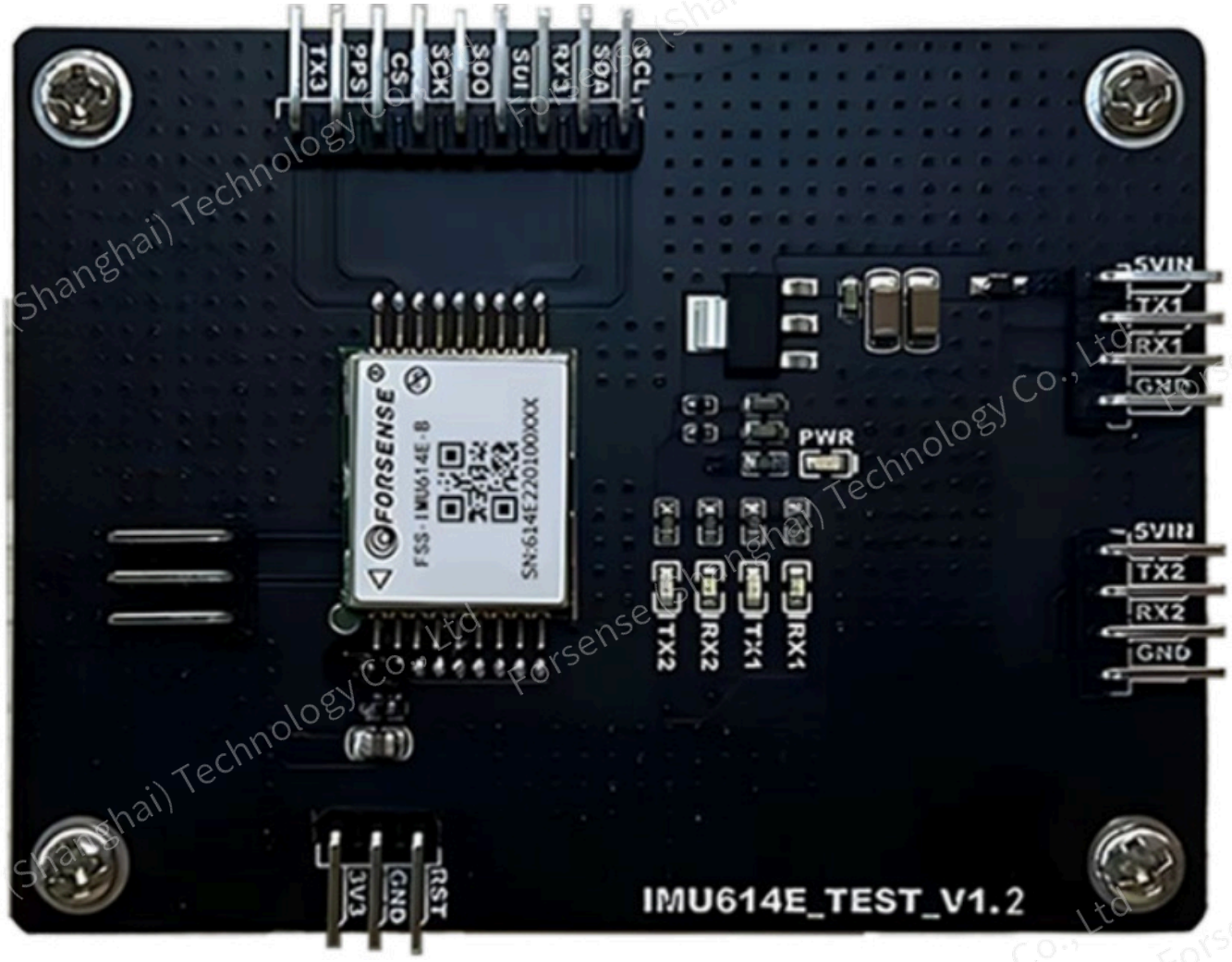
10.2 carrier tape

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

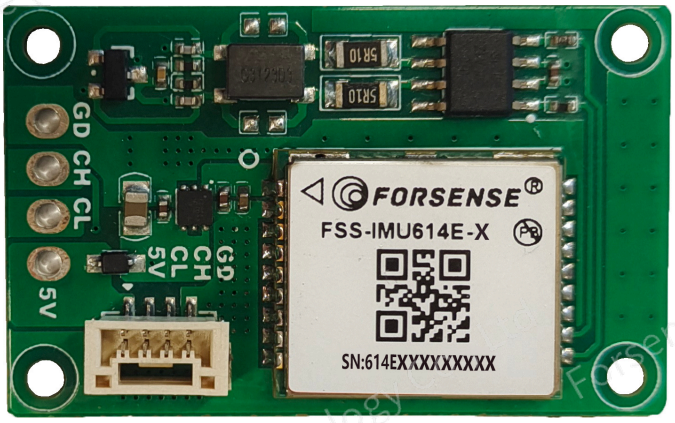
Figure 19 Module Position and Orientation at carrier tape



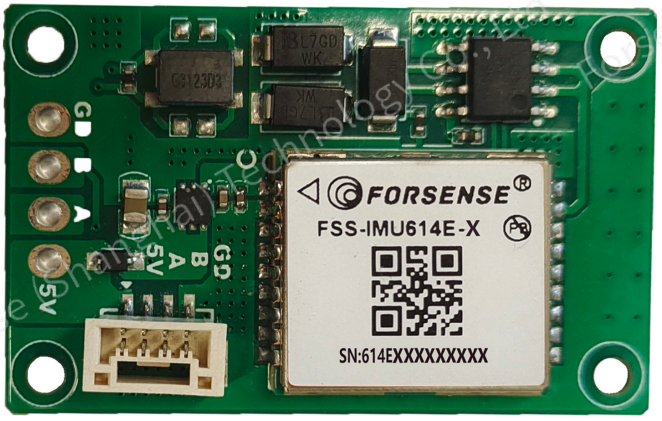
11. OptionalAccessories



IMU614E-X Test Base Plate



SMD CAN Version IMU614E Series Test Base Plate



SMD RS485 Version IMU614E Series Test Base Plate



TTL Serial Port Cable



USB to CAN Module

12. Revision History

Latest Manual Version: IMU614E-B_Datasheet_Product Manual(en)

Version	Date	Status/Comments
Version 1.0	2023.09.15	Initial Release
Version 1.1	2023.10.07	Updated Coordinate System Definition
Version 1.2	2023.11.21	Updated Measurement Range
Version 1.3	2023.12.14	Added Accessories
Version 1.4	2024.02.04	Updated Electrical Characteristics
Version 1.5	2024.02.26	Updated Reflow Soldering Profile and ESD Protection Guidelines
Version 1.6	2024.03.26	Updated Pin Definition
Version 1.7	2024.05.10	Added PC software connection diagram
Version 1.8	2024.06.07	I2C added attitude output
Version 1.9	2024.09.18	Added time synchronization steps
Version 1.10	2025.01.23	Adjusted table and figure numbering and section numbers
Version 1.11	2025.08.01	Simplified Communication Protocol
Version 1.12	2025.12.03	Updated Dimensional Drawings
Version 1.13	2025.12.24	Removed TTL Test Base Plate
Version 1.14	2026.2.10	Updated "SMD CAN Version IMU614E Series Test Base Plate","SMD RS-485 Version IMU614E Series Test Base Plate", "Recommended Pad Size"