FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

IMUP9

Product manual



Forsense (Shanghai) Technology Co., Ltd

Please read this user manual carefully before using this product.

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Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMUP9-Product Manual(en)

Features

Tactical-grade MEMS Gyroscope

- xy:0.4,z:0.3°/hr Bias instability
- 0.015°/√hr Angle Random Walk
- 30°/h Temperature Drift (-40℃ ~ 85℃,≤1℃/min,@1σ)

Tactical-grade MEMS Accelerometer

- 15μg Bias instability
- 0.02m/s/√hr Velocity Random Walk
- 0.5mg Temperature Drift (-40℃ ~ 85℃,≤1℃/min,@1σ)

Wide-Range refined temperature compensation

- -40°C to 85°C Temperature Compensation
- Fine-Tuned Temperature Calibration

independent rotary table calibration

- Independent Calibration of Each Module: Sensitivity, Bias, Misalignment
- User Interface for Installation Error Calibration

High-Stress Operating Condition Tolerance

- Extreme Shock Resistance: 2000g (0.5ms, Half-Sine, 3-Axis)
- Extreme Vibration Resistance: 10g (10~2kHz, 3-Axis)
- Full-Temperature Range Operation: -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 422
- 38.6*44.8*21.5mm, Weight Approx. 48.5g

Product Overview

IMUP9 is a 6 degrees of freedom (DOF) MEMS inertial sensor module developed by Forsense. It provides standard output of three-axis Gyroscope and acceleration data.

High precision and high resolution enable the detection of subtle vibrations and tilts. The wide-range output allows for motion perception 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 various extreme operating conditions.

This also guarantees high consistency in performance across all products.

Application Areas

- Surveying / Mapping
- Underwater Autonomous Vehicles
- Robot
- Ground Unmanned Vehicle



[Important Note]The Z-axis of this product Gyroscope delivers exceptional performance. It is strongly recommended to use the Z-axis as the heading measurement axis for the best experience!

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1. Performance Parameter

1.1 Gyroscope KeyMetrics

Table 1 Gyroscope Key Metrics

Parameter	Test Conditions / Remarks	Min	Typ	Max	Unit
Measurement Range			±300		°/s
Bias instability[2]	@25℃, Allan Variance, 1σ		XY: 0.4 Z: 0.3		°/hr
Bias stability	GJB, 10s Smoothing		XY: 2.5 Z: 0.8		°/hr
Bias Repeatability	GJB		XY:7 Z:3		°/hr
Resolution			0.0003		°/s
Misalignment between axes			0.01		deg
Internal low-pass cutoff frequency	Software Adjustable		68	370	Hz
Sample Rate			1000	1000	Hz
measure delay			5.5		ms
Bias over temperature[1]	-40℃ ~ 85℃, <=1℃/min @1σ		XY: 30 Z: 10		°/hr
Random Walk[2]	@25℃, Allan Variance, 1σ		0.015		°/√hr
scale coefficient error			XY: 1.5 Z: 1.0		‰
scale factor nonlinear			100	200	ppm

Note 1: 1σ value of Bias variation under a heating rate of 1°C/min

Note 2: Based on IEEE standard, Allan variance curve provided in static environment at 25°C

1.2 Accelerometer Key Metrics

Table 2 Accelerometer Key Metrics

Parameter	Test Conditions/Remarks	Min	Typical	Max	Unit
Measurement Range			±8		g
Bias instability[2]	@25℃, Allan Variance, 1σ		15		μg
Bias stability	GJB, 10s Smoothing		25		μg
Bias Repeatability	GJB		0.1		mg
Resolution			0.0159		mg
Misalignment between axes			0.01		deg
Internal low-pass cutoff frequency	Software Adjustable		68	370	Hz
Sample Rate			1000	1000	Hz
measure delay			5.5		ms
Bias over temperature[1]	-40℃ ~ 85℃, <=1℃/min @1σ		0.5		mg
Random Walk[2]	@25℃, Allan Variance, 1σ		0.02		m/s/√hr
scale coefficient error			0.2		‰
scale factor nonlinear			50		ppm

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

Note 2: IEEE standard, ALLAN variance curve provided in a static environment at 25°C

Figure 1 Typical Curve of Gyroscope Allan Variance

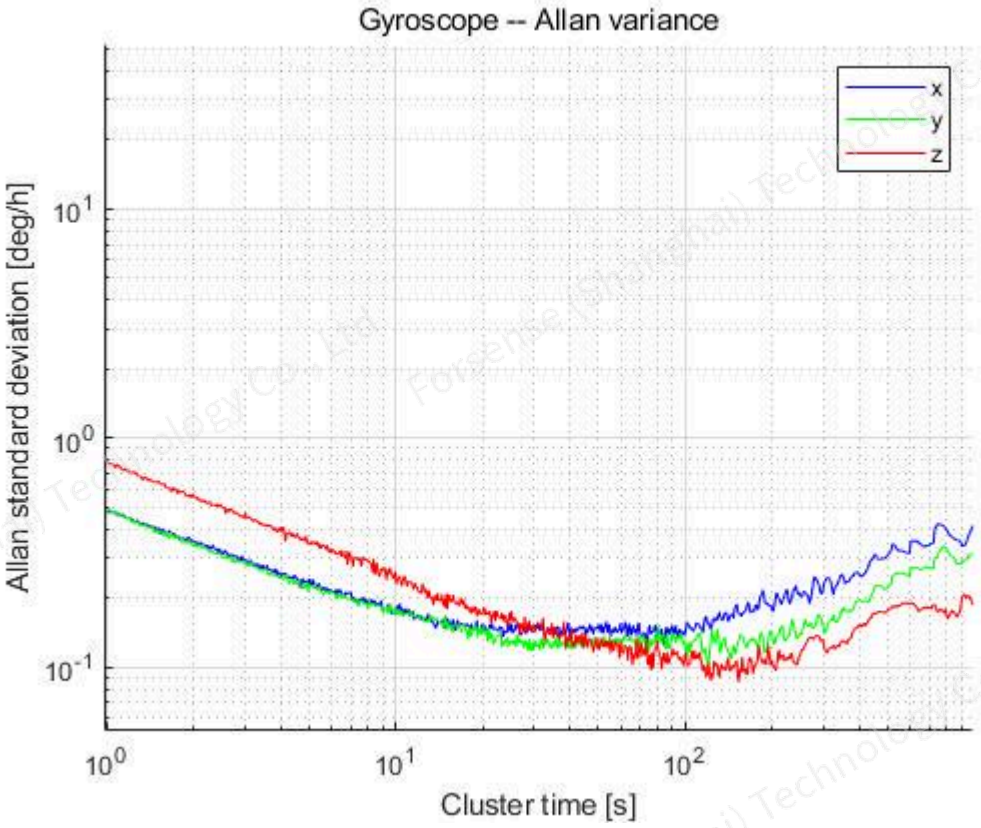
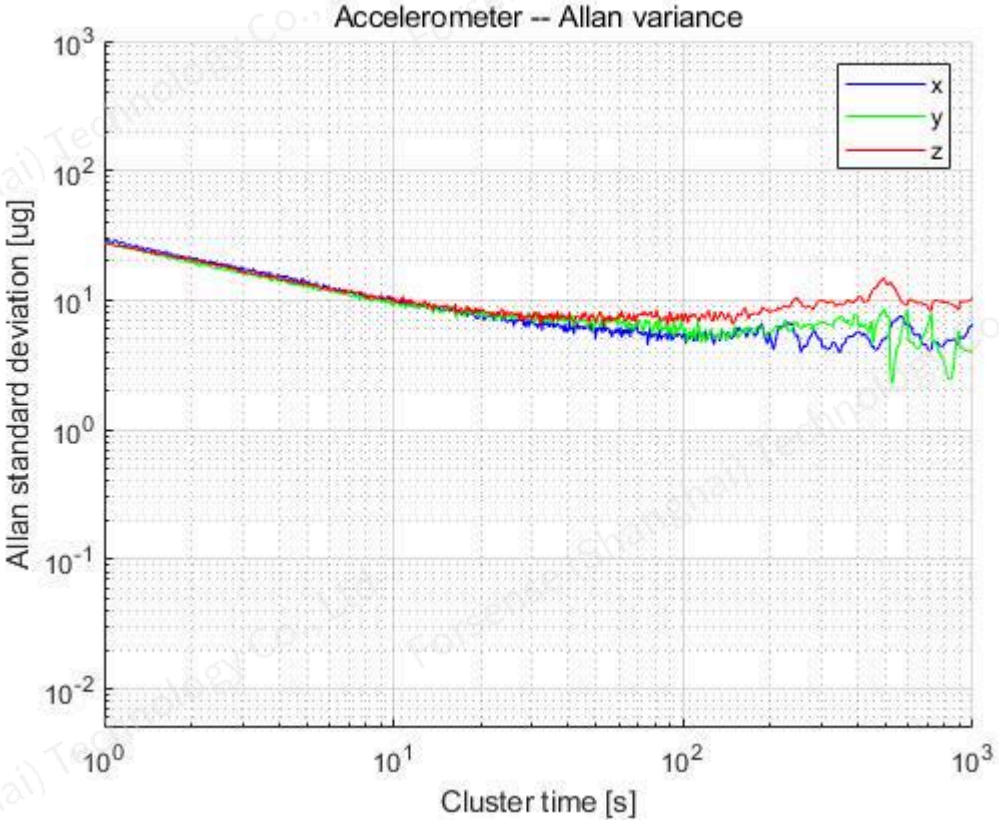


Figure 2 Typical Curve of Accelerometer Allan Variance



2. Mechanical Structure

Figure 3 Mechanical Structure and Dimensions (Unit: mm)

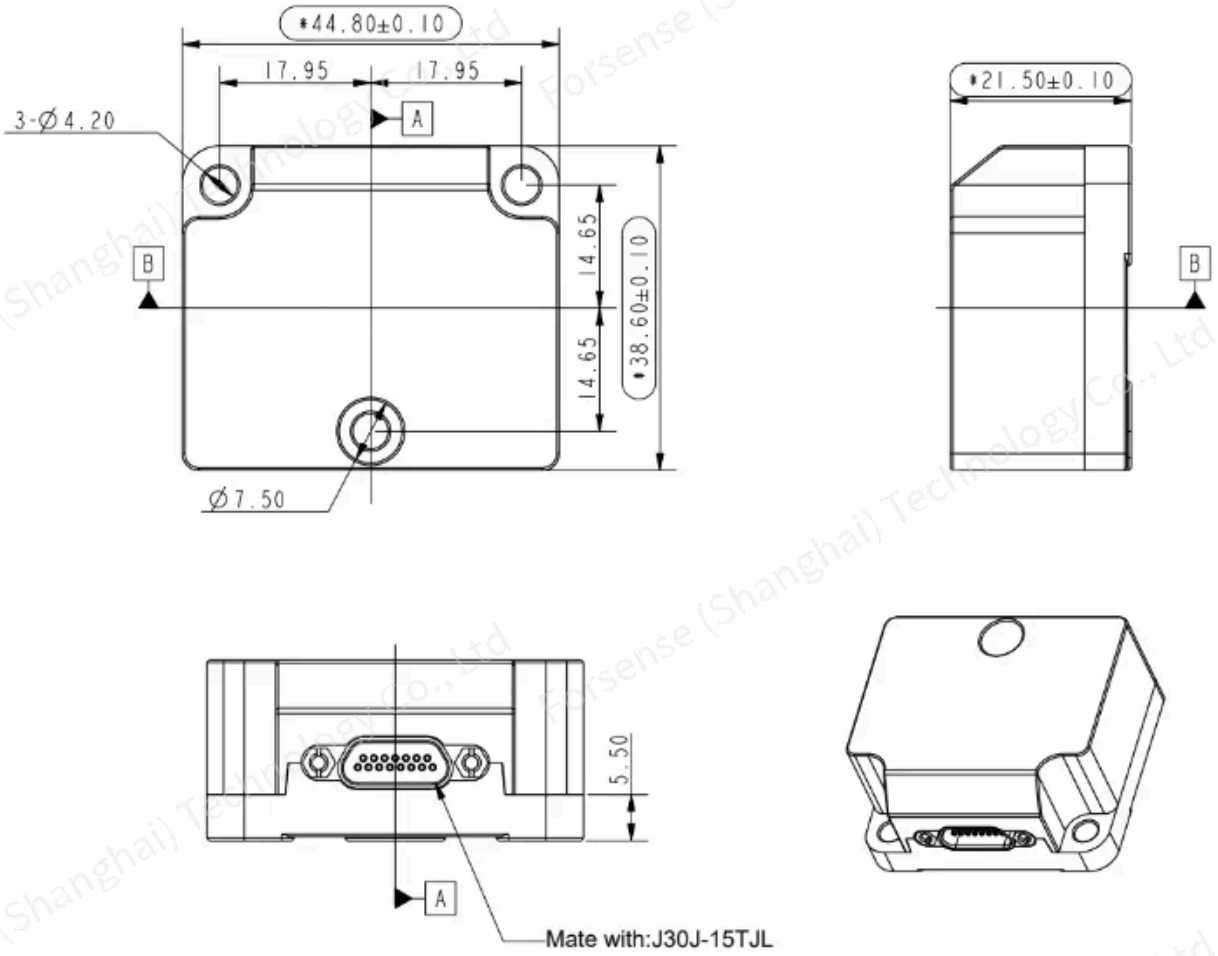
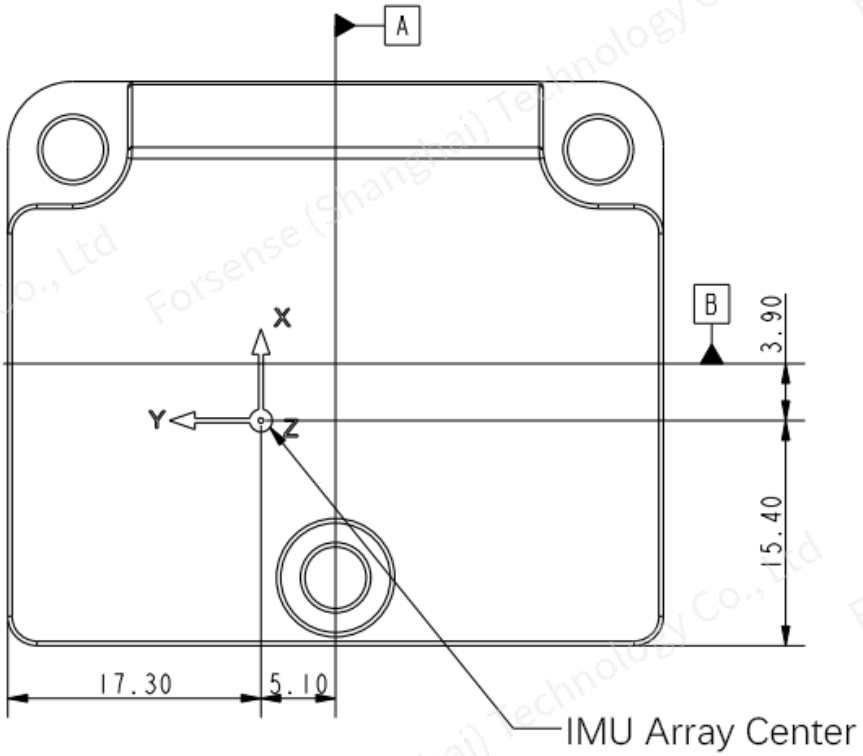
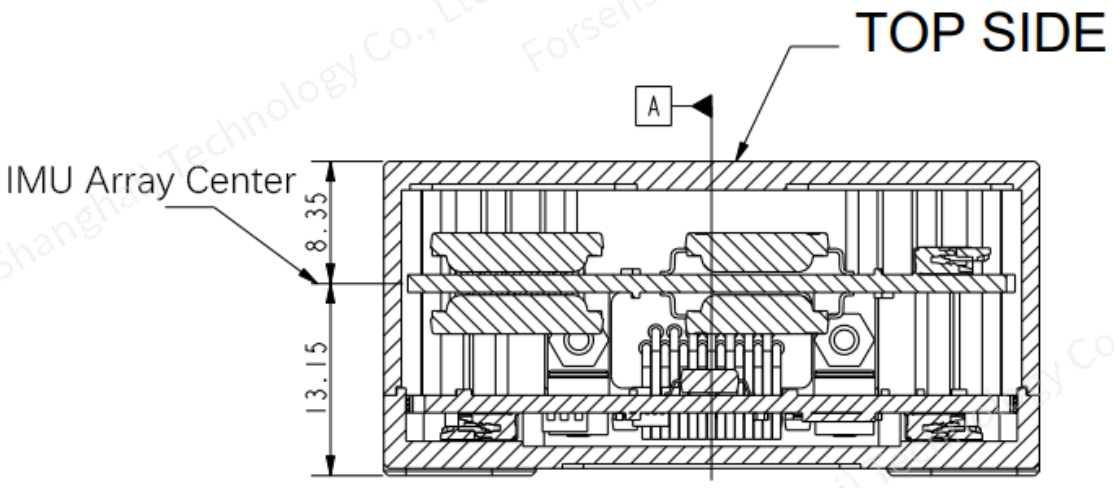


Figure 4 IMU Measurement Center Location (Unit: mm)

TOP SIDE


A
B
X
Y
Z
3.90
15.40
17.30
5.10
IMU Array Center


TOP SIDE
A
IMU Array Center
8.35
13.15

3. Specifications

3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

Parameter	Level	Remarks
Storage Temperature	-55℃-90℃	
VSUP to GND	-0.5-6.5V	
Operating Temperature (Tot)	-40-+85℃	
RXD+/RXD- to GND	-7.5V~12.5V	Termination Resistor 120 Ω
RXD+ to RXD-	±6V	
TXD+/TXD- to GND	-7.5V~12.5V	
ExtTrig to GND	-0.3V-7V	
NRST to GND	-0.3V-7V	
DATA READY to GND	-0.3V-7V	

3.2 EMC

Table 4 EMC

Test Item	Test Standard
CE	Compliant with EN55032 CISPR 16-2-1
CS	Compliant with EN55035 EN(IEC) 61000-4-6
EFT	Compliant with EN55035 EN(IEC) 61000-4-4
RE	Compliant with EN55032 CISPR 16-2-3
RS	Compliant with EN55035 EN(IEC) 61000-4-3
ESD	Compliant with EN55035 EN(IEC) 61000-4-2

3.3 ESD Level

Table 5 ESD Level

	Test Mode	Test Standard	Test Level
V(ESD) Electrostatic discharge (ESD)	Contact Discharge	Compliant with EN(IEC) 61000-4-2	±8 KV
	Air Discharge		±15 KV

4. Electrical Characteristics

Table 6 Electrical Characteristics

Parameter	Conditions	Min.	Typ.	Max.	Unit
Power Supply Input		4.5	5	5.5	V
Power			1.08		W
Storage Temperature		-55		90	℃
Operating Temperature (Tot)		-40		85	℃
RS422 Input Resistance			120		Ω
RESET(NRST PIN)	High	2.3			V
	Low			0.6	V
NRST Internal Pull-up Resistor			4.7		KΩ
Data Ready			3.3		V
ExtTrig	High	2.3			V
	Low			0.6	V

Note: When the supply voltage exceeds 6V, the internal voltage protection circuit cuts off power and puts the device into reset state until the voltage returns to operating conditions, restoring normal operation.

5. Pin Definition

Figure 5 Pin Schematic

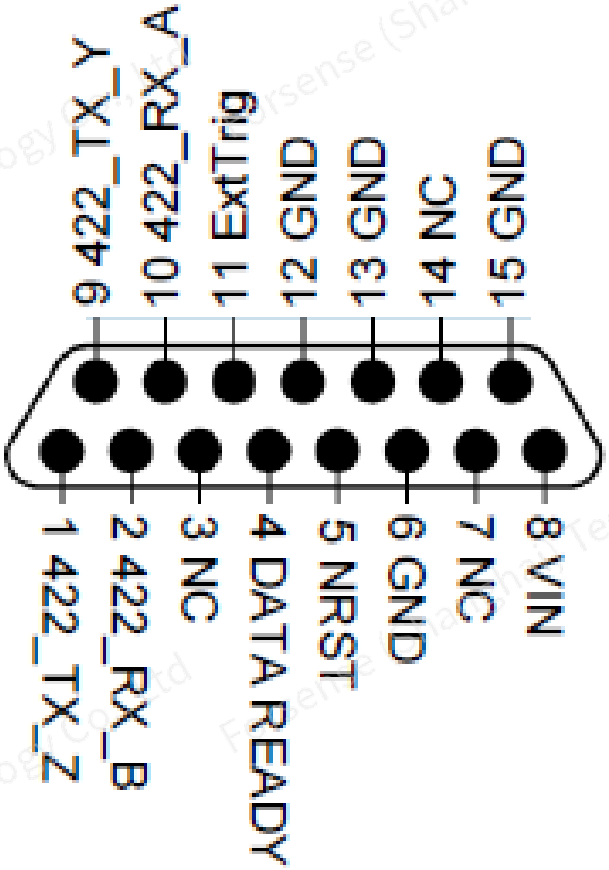


Table 7 Pin Definition

Pin No.	Pin Name	Pin Description
1	422_TX_Z	RS-422,TXD-
2	422_RX_B	RS-422,RXD-
3	NC	Not Connected
4	DATA READY	Data Ready
5	NRST	External Hardware Reset Input, Internal Pull-up
6	GND	Signal Ground
7	NC	Not Connected
8	VIN	Power Input, +5V Input
9	422_TX_Y	RS-422,TXD+
10	422_RX_A	RS-422,RXD+
11	ExtTrig	External Trigger pps
12	GND	Ground (GND)
13	GND	Ground (GND)
14	NC	Not Connected
15	GND	Ground (GND)

6. Recommended Connection Method

Figure 6 Block Diagram of Normal Acquisition Mode

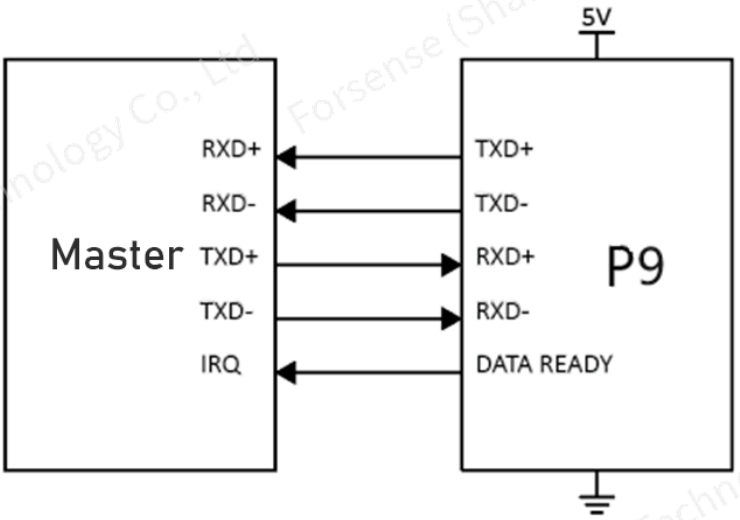
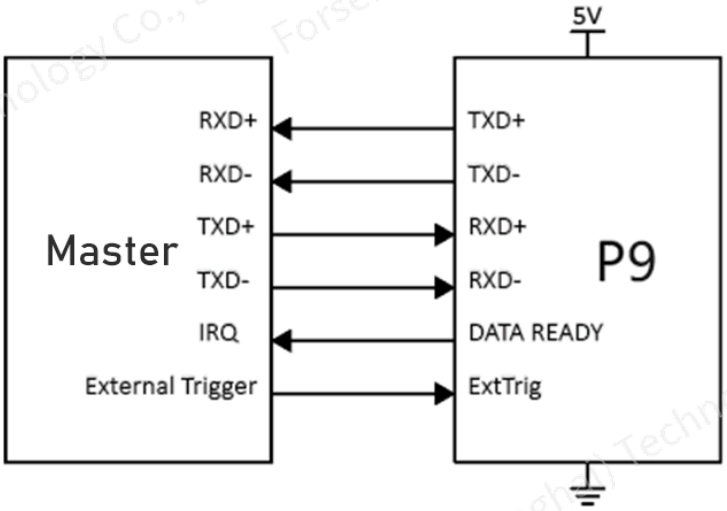


Figure 7 Triggered Acquisition Mode Block Diagram



7. serial communication protocols

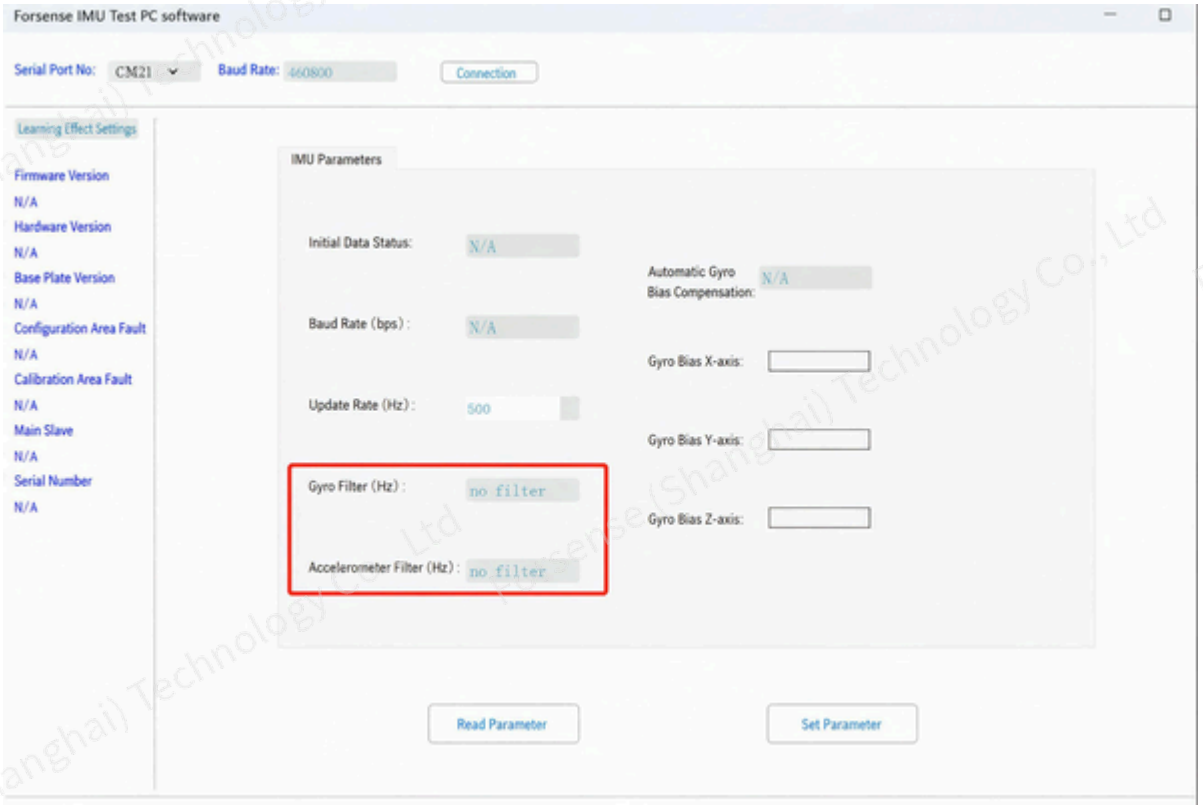
Reference Document Forsense IMU Communication Protocols（en）

Includes serial communication protocols, Coordinate System Settings, Filter Settings, Parameter Settings, OTA Update Method, Time Synchronization, etc.

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8. Precautions for Post-Processing

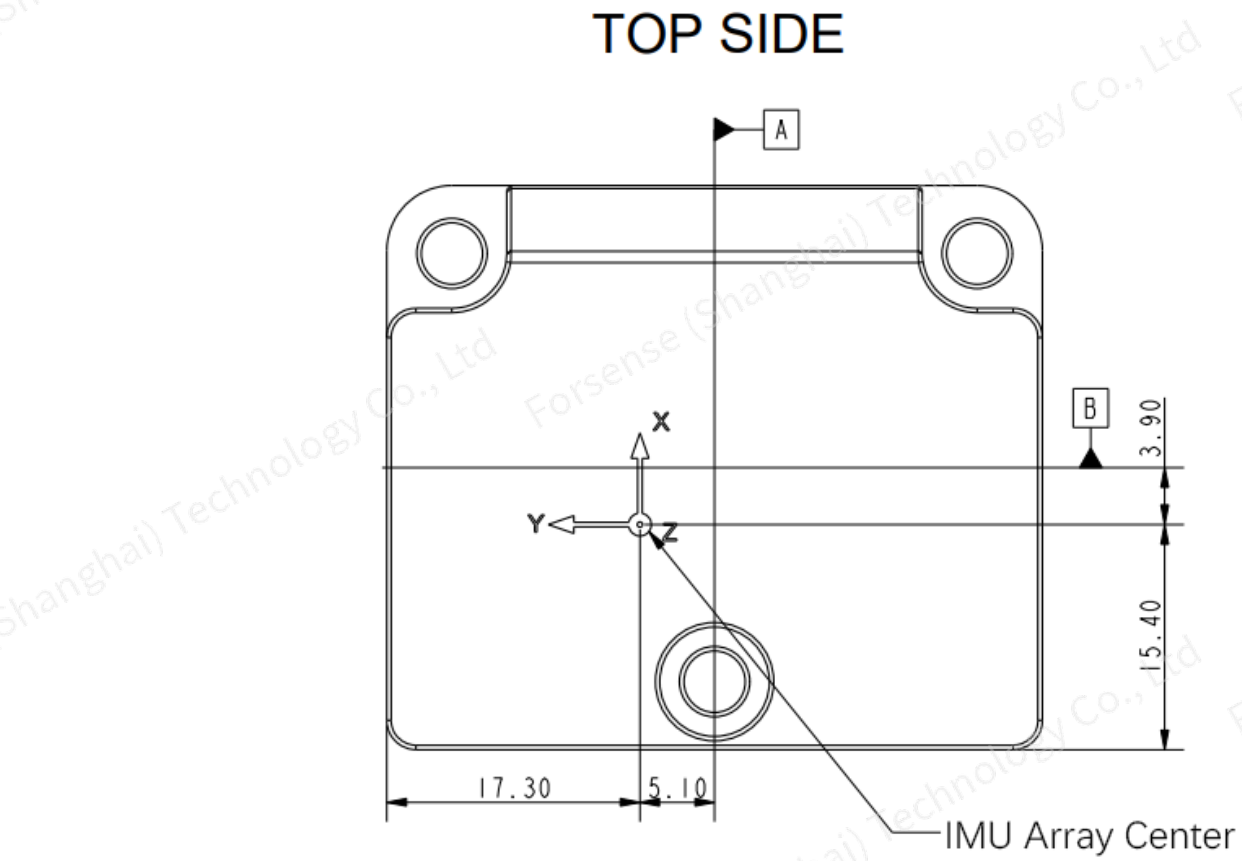
1. Confirm that all filters are set to no filter (keep a screenshot for records). Update Rate is generally set to 500 Hz (minimum 250 Hz), which can be verified via PC software or queried using commands. For specific commands, refer to the 7.6 Command Mode SET command or Section 7.10 Common AT Commands.

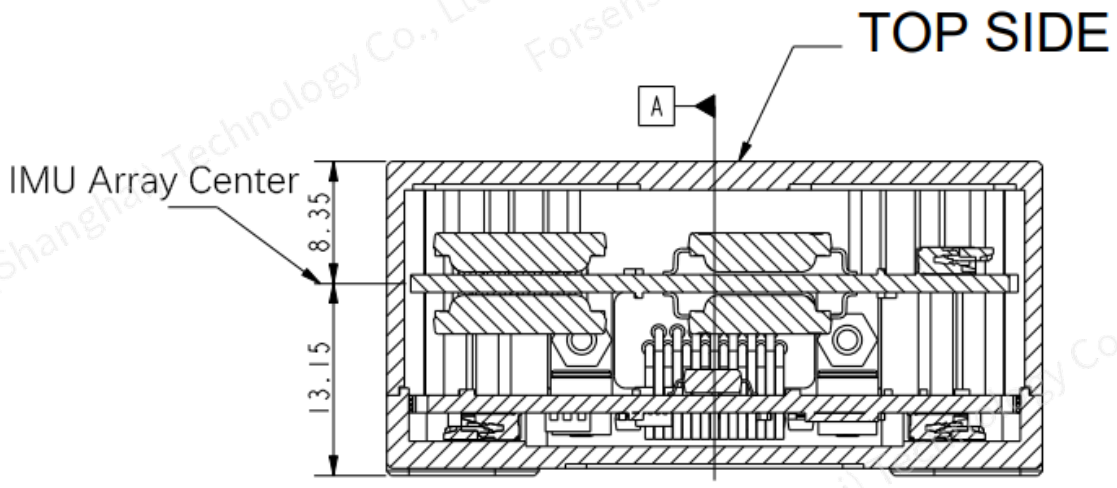


2. P9 data output has a 5.5 ms delay, which must be subtracted when timestamping with the DRDY signal.

3. Lever Arm Configuration

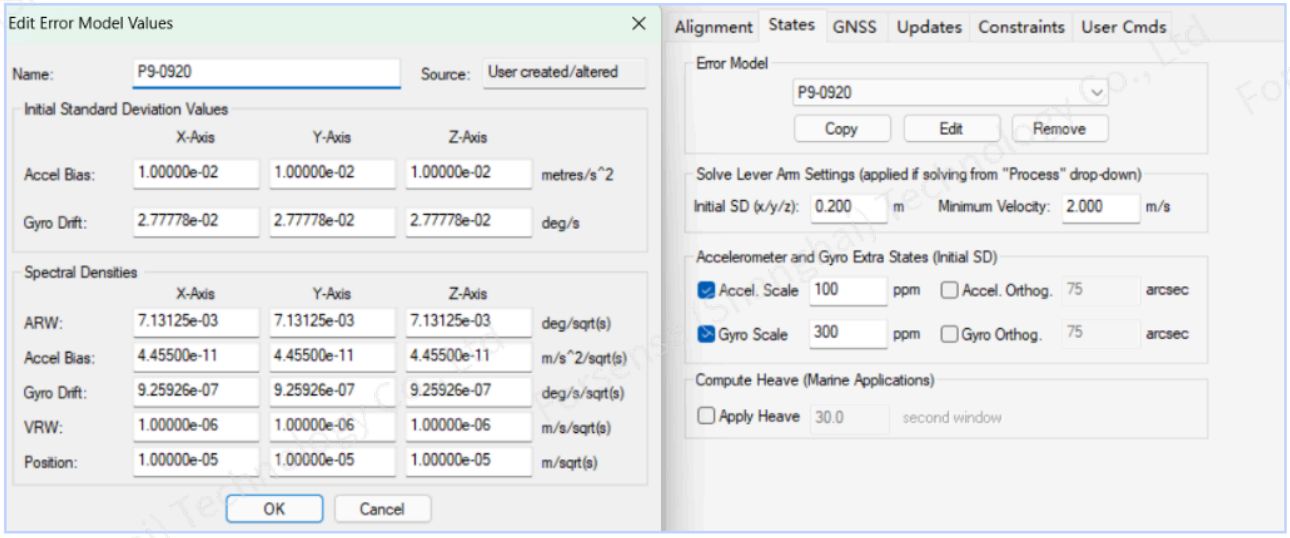
Note: The physical center point of the P9 IMU is shown in the figure below. Pay attention to this when configuring lever arms.



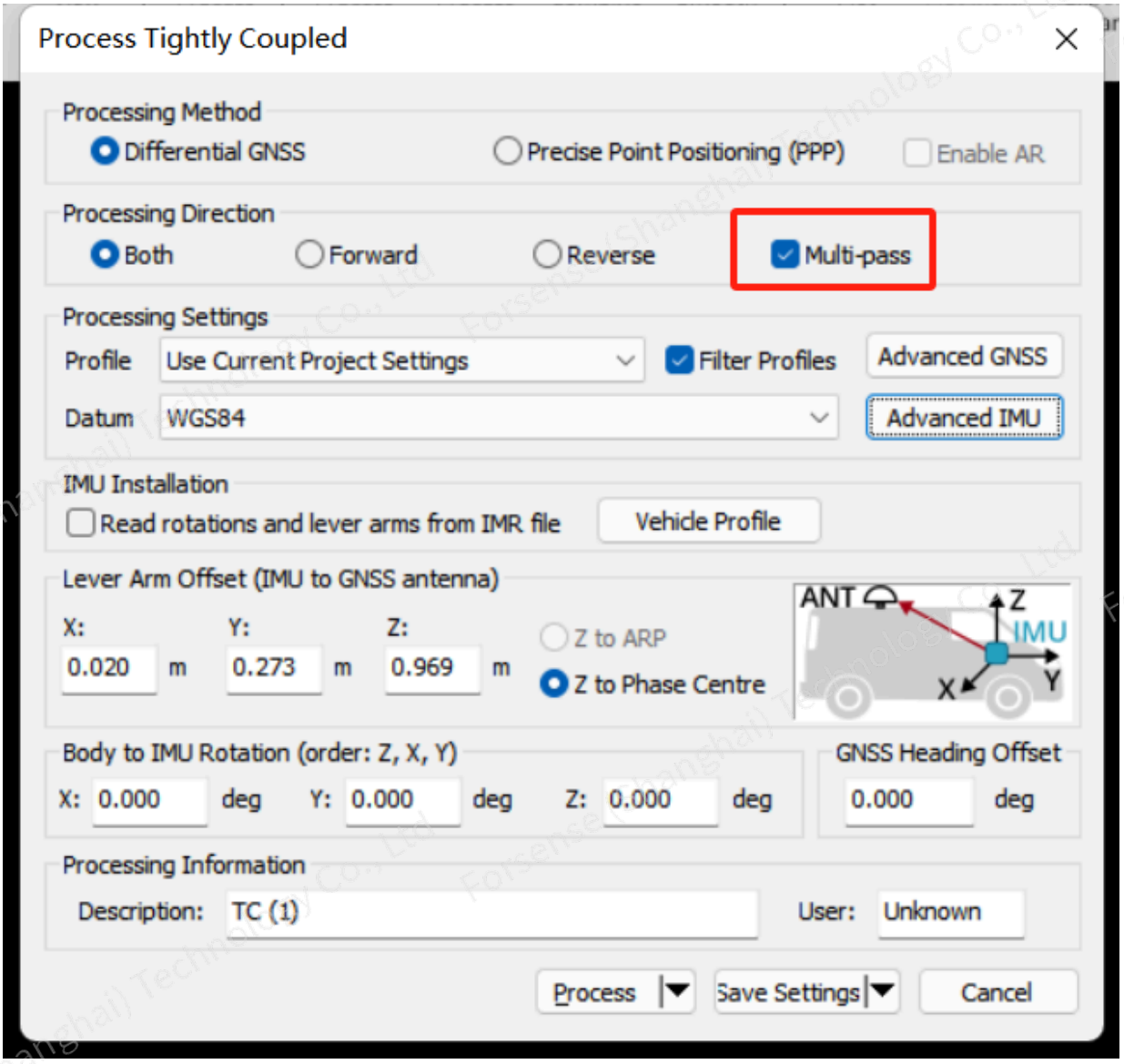


4. Data Processing

(1) Use the following P9 Parameter, and check the configuration shown in the figure below



② When processing IE, select the configuration shown in the figure below.



5. Recommended Flight Modes

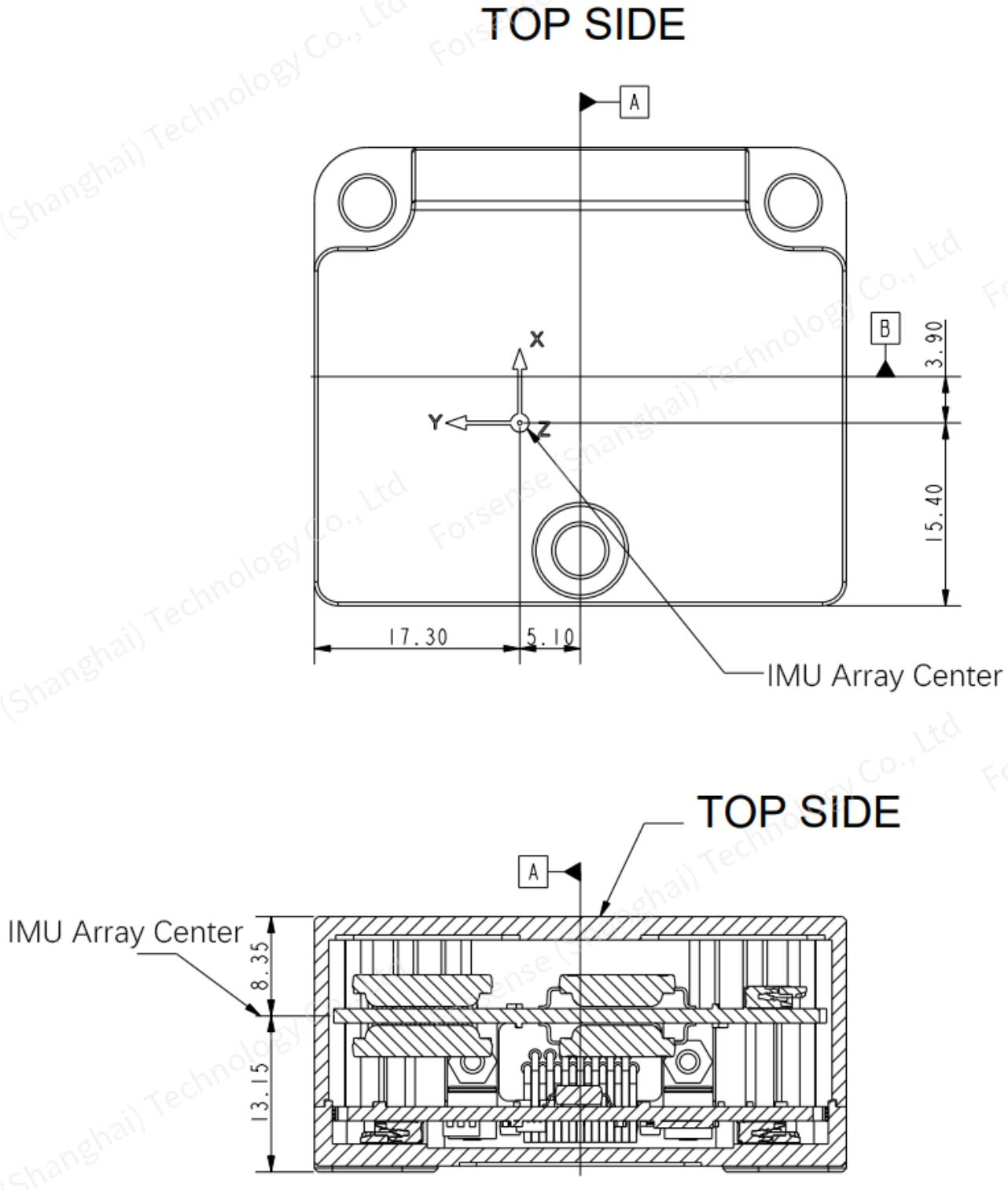
Static before takeoff, figure-eight maneuvers forward and backward, static after landing

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9. Coordinate System Definition

The coordinate system definition of P9 is as follows:Right-Forward-Up coordinate system.

Figure8P9 Coordinate System Diagram



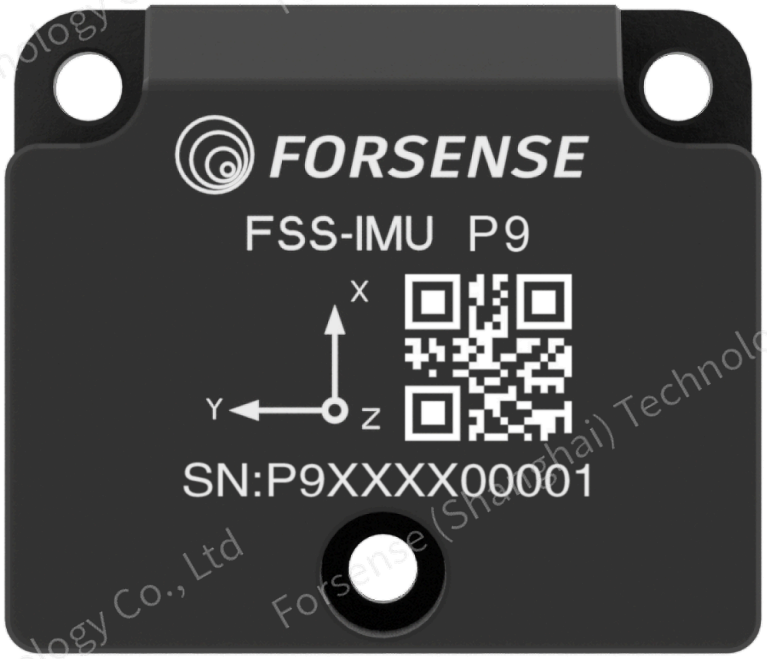
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10. Usage Example

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

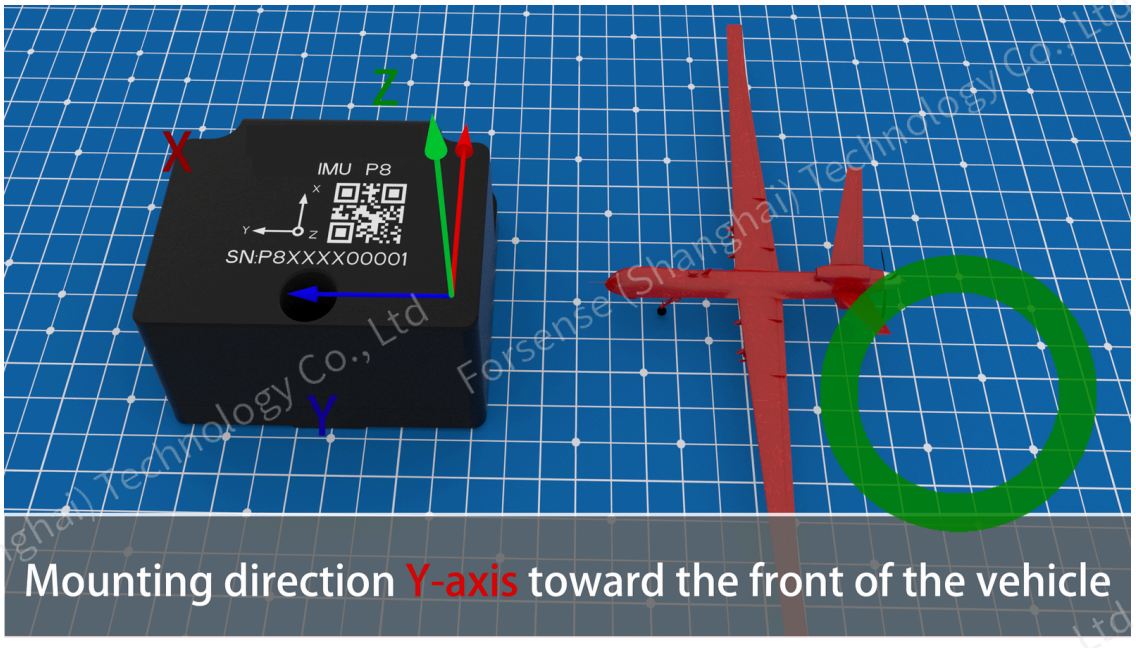
2. The module's mounting orientation should be consistent with the vehicle's forward direction.

Figure9Module Installation Diagram

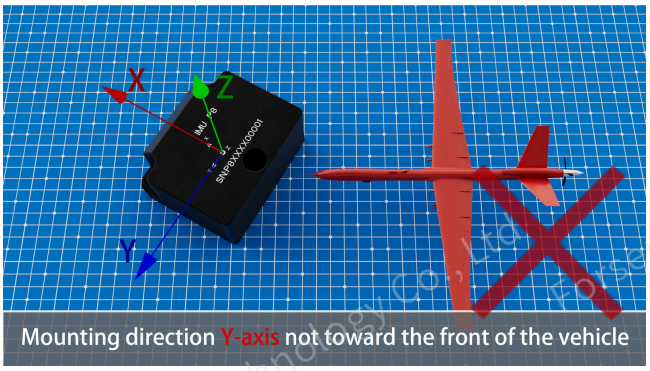


The correct installation diagram is shown below

Y-axis points toward the front of the vehicle

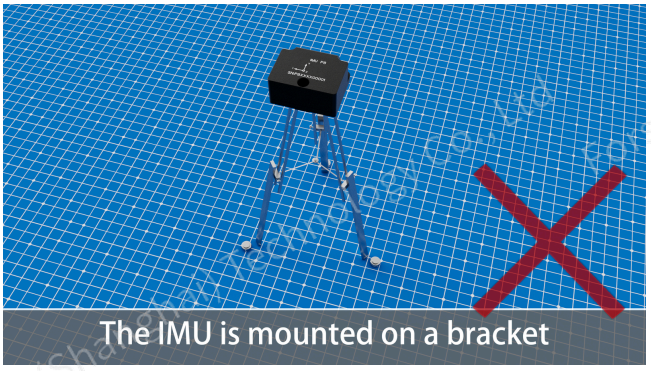


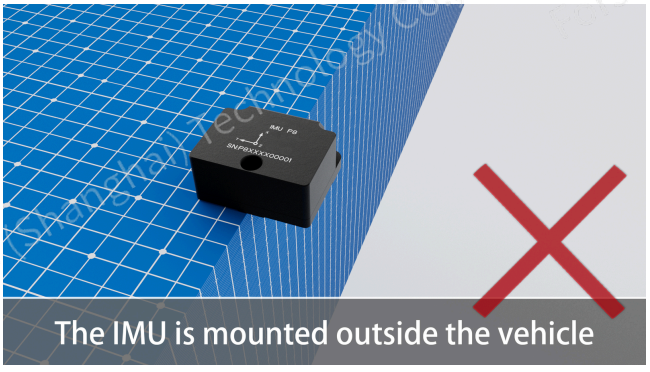
All following installation methods are incorrect

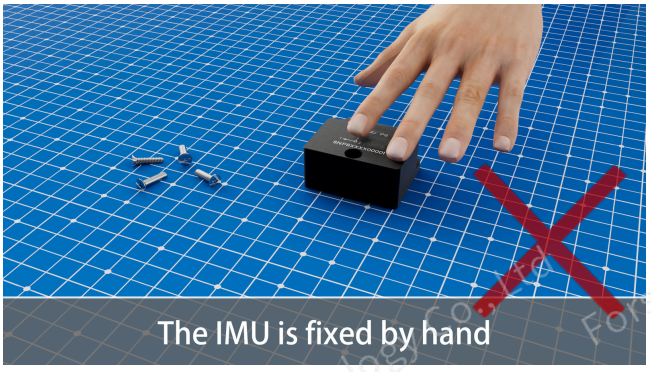




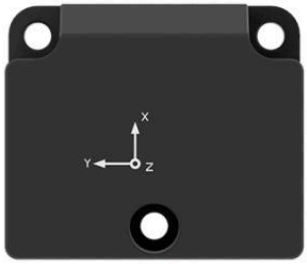








PC software connection diagram



1



2



3

	Name	Quantity
1	IMUP9	1
	Accessories Name	Quantity
2	422 and IMUP9 Signal Adapter Cable	1
3	422 Serial Cable Built-in 5V Power Supply	1

11. Optional Accessories





RS-422 to P9 Signal Adapter Cable

12. Update History

Latest Manual Version: IMUP9_Datasheet_Product Manual(en)

Version	Date	Status/Notes
Version 1.0	2024.08.13	Initial Release
Version 1.1	2025.01.23	Updated Post-Processing Configuration Parameter
Version 1.2	2025.08.04	Simplified Communication Protocol

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