FORSENSE
原极科技

Tactical MEMS 6 degrees of freedom inertial sensor

FSS-IMUP8_PRO Product manual

Features

Tactical grade MEMS Gyroscope

- 0.35°/hr zero bias instability
- 0.08°/√hr Angle random walk
- 30°/ hr temperature drift (-40 ~ 85°C, <=1°C/ min@1σ)

Tactical MEMS Accelerometer

- 15μg zero-bias instability
- 0.03m/s/√hr velocity random walk
- 1mg temperature drift (-40 ~ 85°C, <=1°C/ min@1σ)

Large range of fine temperature compensation

- -40°C to 85°C temperature compensation
- Fine temperature calibration
- Independent turntable calibration
- Independently calibrate each module: sensitivity, Bias instability, Misalignment
- Provide user calibration installation error interface

High strength working condition tolerance

- Strong impact tolerance: 2000g (0.5ms, half sine, 3 axis)
- Strong vibration tolerance: 10g (10~2KHz, 3 axis)
- Full temperature environment stable operation: -40°C ~ 85°C
- 100% magnetic shielding

Real-time and flexible digital interface, small size

- Configurable output sampling rate up to 500Hz
- Supports COM 422
- 38.6*44.8*21.5mm, weighs about 72.5g

Product Overview

IMUP8_Pro is a 6 degrees of freedom (DOF) MEMS inertial sensor module built by Forsense technology. Three-axis Gyroscope and acceleration information are provided as standard.

High precision, high resolution, can capture subtle vibration and tilt. Large range output makes motion perception possible under large dynamics. All

modules are equipped with ultra-wide temperature range of fine warming and independent calibration before delivery, so that each module can play stably in various extreme conditions, while ensuring the performance of all products is highly consistent.

Application field

- Aerial mapping

On the basis of standard performance and output Parameter, Yuanji also provides customized software and LOGO customization services for your special needs, to help you in the product!

Contents

1. Performance Parameter

1.1 Key indicators of Gyroscope

Table 1 Key indicators of Gyroscope

Parameter	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measurement Range			+ 300		°/s
Bias instability	@25℃, Allan Variance, 1σ		0.35		°/hr
Misalignment			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		75		Hz
Sampling rate			500		Hz
measured delay			7.2		ms
Offset error over temperature	-40℃ ~ 85℃ ≤1℃/ min@1σ		30		°/hr
Random Walk on the X-axis	@25℃, Allan Variance, 1σ		0.08		°/√hr
Random Walk Y-axis			0.08		°/√hr
Random Walk Z-axis			0.08		°/√hr
scale coefficient error			1.0		‰
scale factor nonlinear			200		ppm

Note The total temperature Bias instability changes by 1σ at 1:1 ℃/ min

Note 2: IEEE standard, Allan variance curve given at static 25℃ environment

1.2 Key indicators of Accelerometer

Table 2 Key indicators of Accelerometer

Parameter	Test conditions/Remarks	Minimum value	Typical value	Maximum value	unit
Measuring range			Plus or minus 6	Optional ±20	g
Bias instability instability	@25, Allan Variance, 1σ		15		Mug
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		75		Hz
Sampling rate			500		Hz
Measuring delay			7.2		ms
Offset error over temperature	-40℃ ~ 85℃ ≤1℃/ min@1σ		1.0		mg
Random Walk on the X-axis	@25℃, Allan Variance, 1σ		0.03		m/s/√hr
Random Walk Y-axis			0.03		m/s/√hr
Random Walk Z-axis			0.03		m/s/√hr

Note The total temperature Bias instability changes by 1σ at 1:1 ℃/ min

Note 2: IEEE standard, Allan variance curve given at static 25℃ environment

FIG. 1 Typical curve of Gyroscope Allan Variance

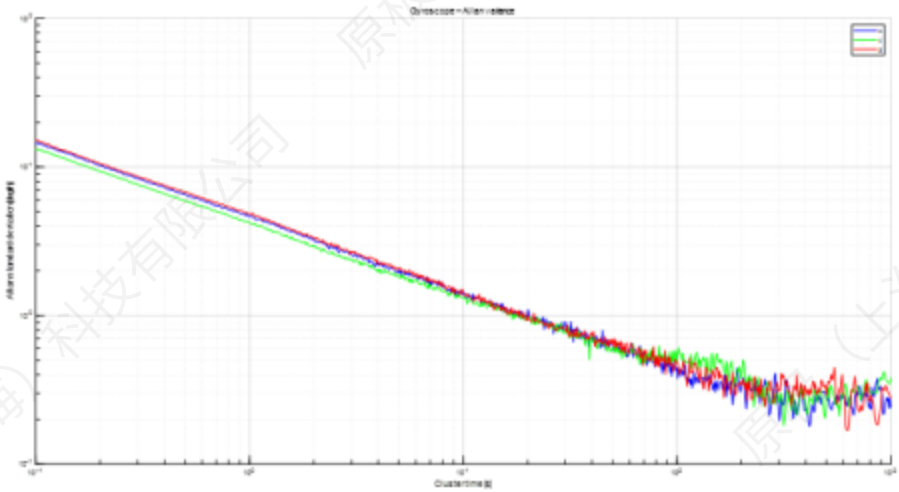
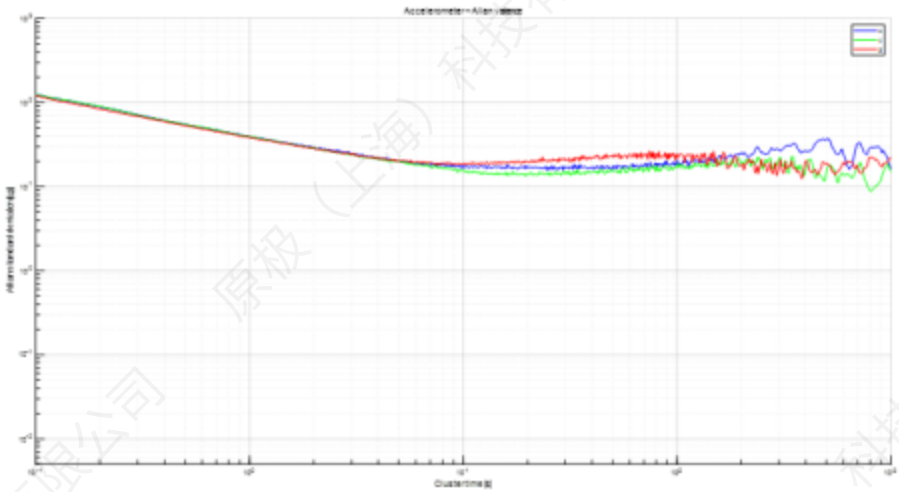


FIG. 2 Typical curve of Accelerometer Allan Variance



2. Shape and structure

Figure 3 Outline structure and size (unit: mm)

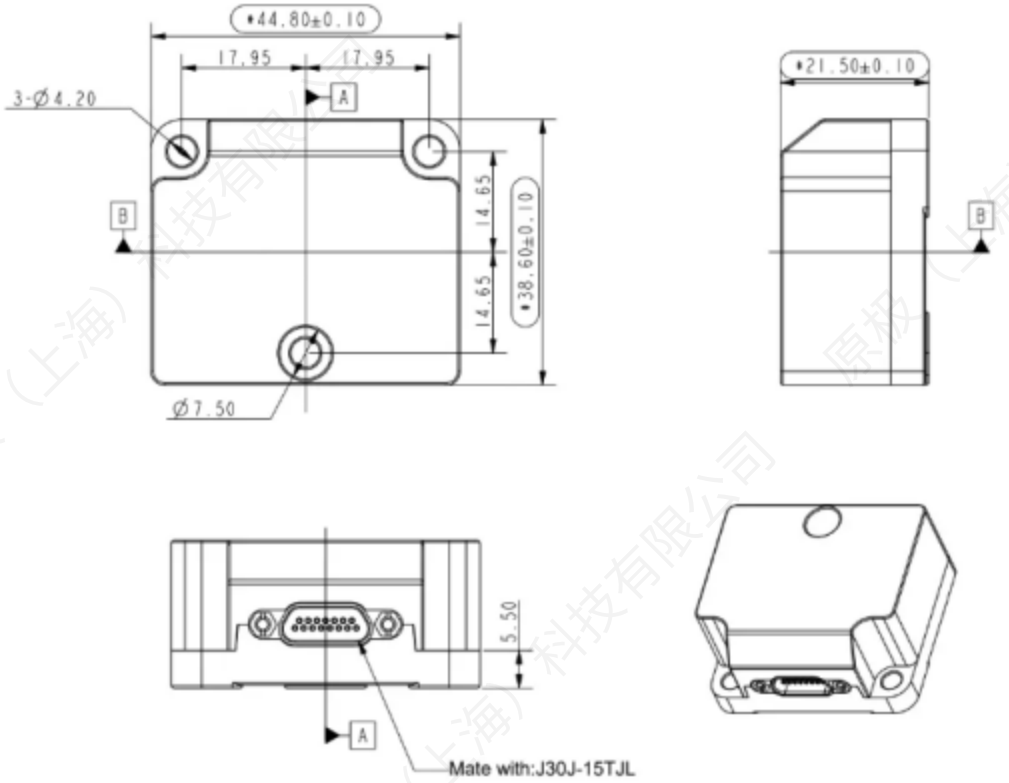
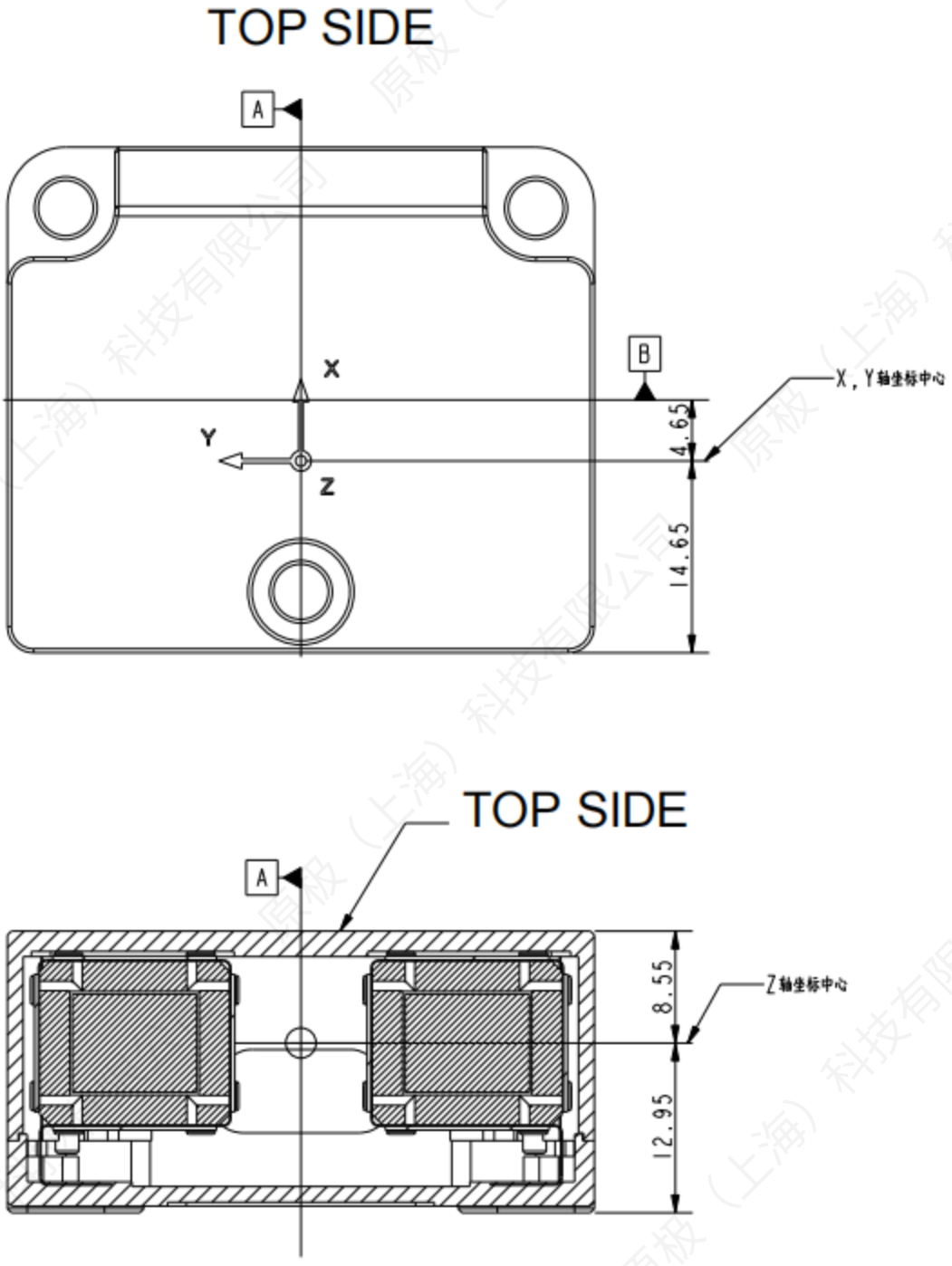


Figure 4 Location of IMU measurement center (unit: mm)



3. Specifications

3.1 Maximum absolute rated value

Table 3 Absolute maximum rating

Parameters	Levels	Remarks
Storage temperature	And 55 ℃ to 90 ℃	
VSUP to GND	-0.5-6.5 V	
Use temperature	-40 - + 85 ℃	
RXD+/RXD- to GND	7.5 V to 12.5 V	Match resistance 120Ω
RXD+ to RXD-	±6V	
TXD+/TXD- to GND	7.5 V to 12.5 V	
ExtTrig to GND	0.3 V - 7 V	
NRST to GND	0.3 V - 7 V	
DATA READY to GND	0.3 V - 7 V	

3.2 EMC

Table 4 EMC

Test Items	Test criteria
CE	Comply with EN55032 CISPR 16-2-1
CS	Comply with EN55035 EN(IEC)61000-4-6
EFT	Comply with EN55035 EN(IEC)61000-4-4
RE	Comply with EN55032 CISPR 16-2-3
RS	Meets EN55035 EN(IEC)61000-4-3
ESD	Complies with EN55035 EN(IEC)61000-4-2

3.3 ESD Rating

Table 5 ESD rating

V (ESD) Electrostatic discharge	Test mode	Test standard	Test grade
	Contact discharge	Comply with EN(IEC)61000-4-2	±8 KV
	Air discharge		±15 KV

4 Electrical characteristics

Table 6 Electrical characteristics

Parameters	Conditions	Minimum	Typical	Max	Units
Power input		4.5	5	5.5	V
Power			1		W
Storage temperature		-55		90	℃
Operating Temperature (Tot)		-40		85	℃
RS422 input resistor			120		Ω
RESET(NRST PIN)	High	2.3			V
	Low			0.6	V
NRST internal pull-up resistor			4.7		K Ω
Data Ready			3.3		V
ExtTrig	High	2.3			V
	Low			0.6	V

Note: When the supply voltage is higher than 6V, the internal voltage protection circuit will cut off the power supply and the device will enter the reset state until the voltage returns to the operating condition and resume work.

5. Pin definition

Figure 5 Pin diagram

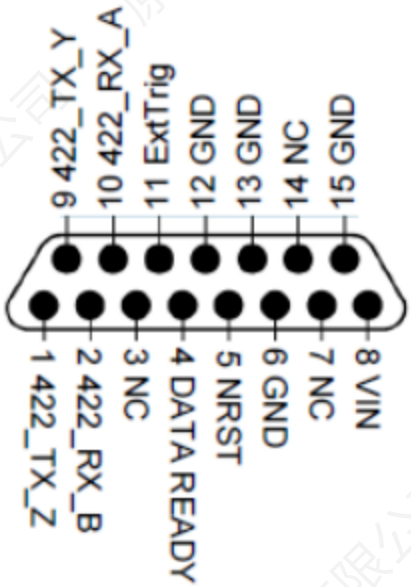


Table 7 Pin definitions

Pin serial number	Pin name	Pin description
1	422_TX_Z	RS-422, TXD-
2	422_RX_B	RS-422, RXD-
3	NC	Not pick up
4	DATA READY	Data Ready
5	NRST	External hardware reset input, internal pull-up
6	GND	Signalland
7	NC	Not pick up
8	VIN	Power input, +5V input
9	422_TX_Y	RS-422, TXD+
10	422_RX_A	RS-422, RXD+
11	ExtTrig	External trigger
12	GND	Power ground
13	GND	Power ground
14	NC	Not pick up
15	GND	Power ground

Recommended connection method 6

Figure 6 Block diagram of normal acquisition mode

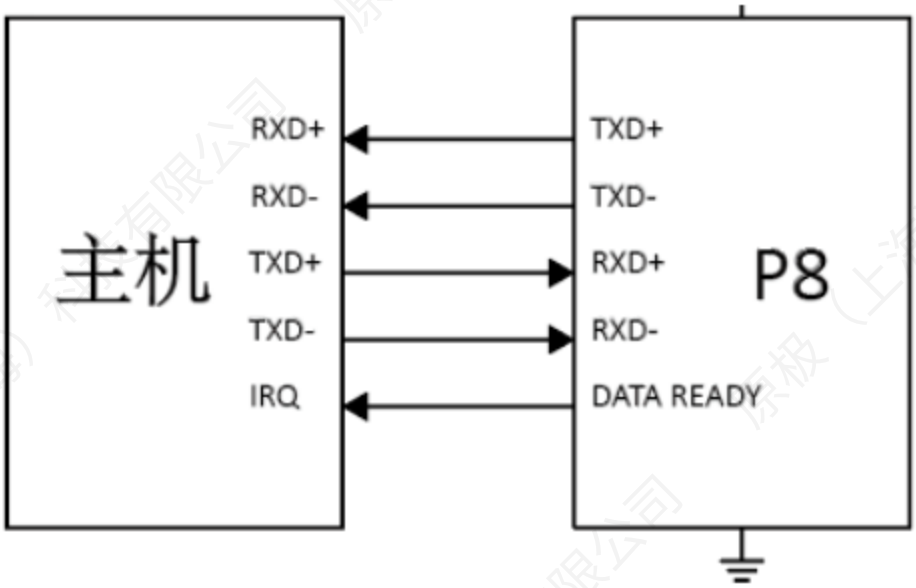


Figure 7 Block diagram of trigger acquisition mode

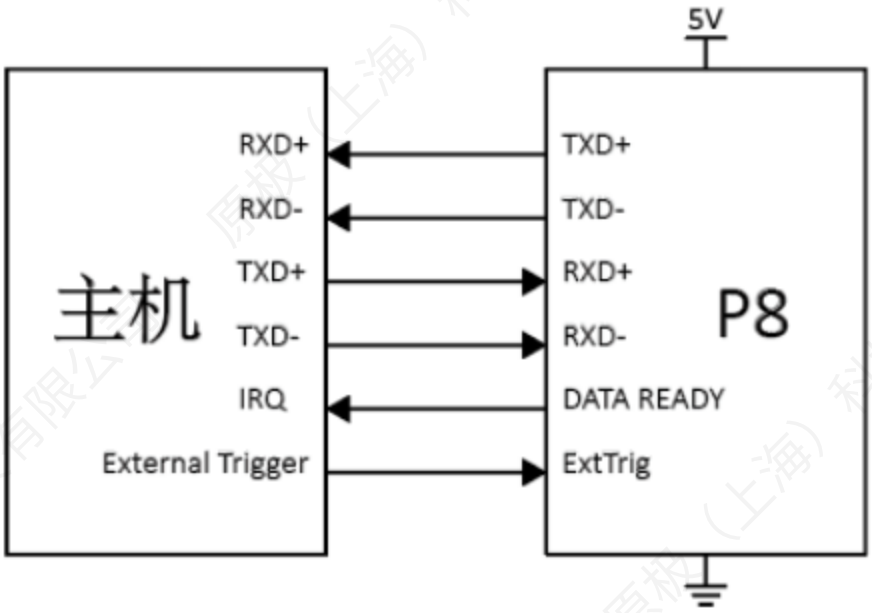


Figure 8 Time synchronization trigger acquisition mode block diagram

7. COM communication protocol

Examples of COM protocols based on QT, ROS and STM32:

https://data.forsense-imu.com/page/download.html

The serial port communication supports two modes: Stream Mode and Command Mode. The IMU enters the corresponding mode according to the mode value configured by parameters after the initialization is complete.

Stream mode: Periodically output AHRS data at a fixed frequency;

Command mode: In this mode, the periodic output is stopped, the user communicates with the IMU by sending commands, and the sensor data, status, parameters, etc. can be obtained through the GET command, and the parameters of the IMU can also be configured.

7.1 Parameters of serial port interface

Table 8 Serial port parameters

Transmission rate range	115200bps to 1.5Mbps
Default transfer rate	115200bps
Start bit	1 bit
Data bits	8 bits
Stop bits	1 bit
Parity check	There is no

7.2 Packet Format

The packet structure of IMU output and user input is composed as follows:

Table 9 IMU output and user input data structures

Offsets	Data type	Name	Description
0	uint8	Frame Header 1	IMU Output frame headers: 0xAA, 0x55 User input frame header: 0x55, 0xAA
1	uint8	Frame header 2	
2	uint16	ID low	The low bit of the frame ID for serial communication
3		ID high byte	The high byte of the serial port frame ID
4	uint16	Data length low	The low byte of the frame length for serial communication, length is the number of bytes carried by payload, that is, n
5		High data length	High byte of frame length for serial communication, length is the number of bytes carried by the payload, that is, n
6	uint8	Payload (n bytes)	Data load
6+n	Uint32	CRC_CEHCK (32-bit data low byte)	CRC check
7+n		CRC_CEHCK (Low byte in 32-bit data)	
8+n		CRC_CEHCK (High byte in 32-bit data)	
9+n		RC_CEHCK (32-bit data high byte)	

Note 1: Data is transmitted in small-endian format, with low bytes first and high bytes last

Note 2: The initial value of crc32 is 1. CRC calculation does not include all the data of this frame itself. See the end of the document for table lookup calculation

7.3 Data Flow frame -- AHRS data

Table 10 AHRS data format of COM

	Frame Headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	A1	uint32
Coding	0xAA	0x55	0x0002	0x002C		crc32

Note 1: Maximum output update rate is not greater than 200Hz@115200bps

Table 11 COM A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	Mu s	Time scale
4	/	/	/	/
8	/	/	/	/
12	/	/	/	/
16	ax	float	g	X-axis acceleration
20	ay	float	g	Y-axis acceleration
24	az	float	g	Z-axis acceleration
28	gx	float	°/s	X axis Angular velocity
32	gy	float	°/s	Y-axis Angular velocity
36	gz	float	°/s	Z axis Angular velocity
40	temp	float	℃	IMU chip temperature

Example: Get AHRS data stream:

AA 55 02 00 2C 00 6D 89 16 05 8F C2 65 40 14 AE 07 BF 5C 0F B2 43 25 06 81 3D BC 74 13 3C 60 E5 80 BF EC 51 38 BD 0A D7 A3 BB CD CC CC BC D7 A3 EE 41 0C BF 84 80

The analysis is as follows:

Table 12 AHRS data flow obtained from COM A1

Description	Raw Value	Analytic value	Description	Raw Value	Analytic value
ID	0200	02	Y-axis acceleration	BC74133C	0.009 g
Length	2C00	44	Z-axis acceleration	60E580BF	1.007 g
Time scale	6D891605	85363053	X axis Angular velocity	EC5138BD	0.045 °/s
Pitch angle	8FC26540	3.59 °	Y-axis Angular velocity	0AD7A3BB	0.005 °/s
Roll angle	14AE07BF	0.53 °	Z axis Angular velocity	CDCCCCBC	0.025 °/s
Yaw angle	5C0FB243	356.12 °	Imu chip temperature	D7A3EE41	29.83 ℃
X-axis acceleration	2506813D	0.063 g	crc32 Check	0CBF8480	2156183308

7.4 Data Stream Frame — AHRS-Q -- Data (quaternion)

Table 13 Serial AHRS data format

	Frame Headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	A1	uint32
Coding	0xAA	0x55	0x0003	0x0034		crc32

Note 1: Maximum output update rate is not greater than 200Hz@115200bps

Table 14 Serial port A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	ms	Time marker
4	q0	float	/	/
8	q1	float	/	/
12	q2	float	/	/
16	q3	float	/	/
20	ax	float	g	X-axis acceleration
24	ay	float	g	Y-axis acceleration
28	az	float	g	Z-axis acceleration
32	gx	float	°/s	X axis Angular velocity
36	gy	float	°/s	Y-axis Angular velocity
40	gz	float	°/s	Z axis Angular velocity
44	temp	float	℃	IMU chip temperature
48	Reserved bits	uint32	/	/

Example: AHRS data flow is obtained:

AA 55 03 00 34 00 1A 99 00 00 E8 EB 7F BF 41 25 75 BA 30 A1 F7 BA AD 21 CA 3C EB E3 7E 3B 94 1F 04 BB C9 19 81 BF 56 C8 8F BB 25 BD DC 3D 8D EF B7 BD 70 3D F0 41 00 00 00 00 82 22 E5 8D

The breakdown is as follows:

Table 15 Serial port A1 obtains AHRS data stream

Description	Raw Value	Analytic value
ID	0300	3
Length	3400	52
Time marker	1A990000	39194
Q0	E8EB7FBF	-0.999693393707275
Q1	412575BA	-0.000935155956540257
Q2	30A1F7BA	-0.00188926421105862
Q3	AD21CA3C	0.0246742609888315
X axis acceleration	EBE37E3B	0.00388931739144027
Y-axis acceleration	941F04BB	-0.00201604235917330
Z-axis acceleration	C91981BF	-1.00859940052032
X axis angular velocity	56C88FBB	-0.00438789557665587
Y-axis angular velocity	25BDDC3D	0.107782639563084
Z axis angular velocity	8DEFB7BD	-0.0898123756051064
imu chip temperature	703DF041	30.0299987792969
Reserved bit	00000000	0
crc32 check	8222E58D	2,380,604,034

7.4 Command Mode GET Output -- System status

Table 16 COM system status data format

	Frame header	Frame header	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	S1	uint32
Coding	0xAA	0x55	0x00FF	N		crc32

Note 1: Depending on the IMU model, the length of this frame will vary, all represent the length of S1, need to be confirmed according to the imu model.

Table 17 Load data format of COM S1

offset	Name	Data type	Description
0	Software_ver	uint32	Software version number
4	Hardware_ver	uint32	Hardware version number
8	rev	uint16	Reserved bytes
10	sn0	uint32	First SN number
14	sn1	uint32	Second SN
18	sn2	uint32	Third SN
22	Board_version	uint32	Baseboard version number
26	Rev[16]	Uint8	The remaining bytes are reserved

Note 1: Reserved bytes vary based on the imu model. The IMU614E is 16 bytes.

For example, obtain the IMU status

Enter data: 55 AA 01 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 BD DB 31 34

Response data: AA 55 FF 00 2A 00 1F 39 03 00 65 6F 01 00 50 83 30 33 35 55 34 50 15 FF 8F 5F FF FF 50 83 FF 1F 29 00 00 00 00 E0 00 07 10 17 08 50 D0 37 10 3B 7A C3 00 02

Based on the response data, the resolution yielded software version number 211231(1F 39 03 00) and hardware version number 94053(65 6F 01 00).

7.5 Command mode GET output -- read Parameter

Table 18 COM Parameter Input data format

	Frame header	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	P1	uint32
Coding	0x55	0xAA	0x0006	0x0018		crc32

Table 19 COM Parameter Output data format

	Frame Headers	Frame Headers	ID	length	payload	Frame trailer
Data type	uint8	uint8	uint16	uint16	P1	uint32
Coding	0xAA	0x55	0x7530	0x0018		crc32

Note 1: When reading Parameter, the IMU will disable the data stream. After the setting is complete, the data stream needs to be restarted.

Table 20 Load data format of COM P1

offset	name	Data type	Description
0	Param1	float	Obtained Parameter (input data can be ignored)
4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the Parameter index
12	Param4	uint32	Reserved, the default value is 0
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Keep, default is 0

Table 21 Index of COM P1 load Parameter

Param3	Param1	Units
3	The COM outputs the baud rate. The following baud rates are supported 115200, 230400, 460800, 921600, 1500000	bps
4	Coordinate system orientation (see Table 25 Coordinate System Orientation correspondence table)	
8	X-axis gyro zero bias calibration results, GYRO_X_OFF	°/s
9	Y-axis gyro zero bias calibration results, GYRO_Y_OFF	°/s
10	Z-axis gyro zero bias calibration results, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, define the same SPI FILTER_CTRL table	

Example: Get AHRS output frequency

Input data: 55 AA 06 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 66 CB 46 AC

Response data: AA 55 30 75 18 00 00 00 00 48 42 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 31 2F A2 0A

According to the response data, the analysis results in an output frequency of 50hz (00 00 48 42).

7.6 Command mode SET instruction

Table 22 COM Input command format

	Frame header	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	R1	uint32
Coding	0x55	0xAA	CMD	0x0018		crc32

Note 1: For details about the relationship between CMD and R1, see the R1 load Parameter index table

Table 23 Load data format of COM R1

offset	Name	Data type	Description
0	Param1	float	Parameters to set
4	Param2	float	Keep, default to 0
8	Param3	uint32	Parameter index of Settings
12	Param4	uint32	Reserved, the default value is 0
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Keep, default is 0

Table 24 Index of Parameter of the COM R1 load

CMD	Param1	Param3	Description
1	0	0	Trigger to get system status data once
2	0	0	Trigger to obtain AHRS data once
3	<mode>	0	< mode > Set the output mode: Mode=1, data stream output AHRS Mode=100: Disables the data flow mode and enters the COMMAD mode
5	0	0	Save the current Parameter to FLASH
6	0	<value>	Read Parameter, value is the index of the Parameter to be read, that is, P1.index, see the COM response output - Parameter read For example, if you want to read AHRS output frequency (ODR), set value=21 For example, to read the baud rate of the COM, set the value to 3 For example, if you want to read the internal filter, set value=31 For example, if you want to read the coordinate system orientation, set value=4
9	0	0	Perform a software restart
14	<value>	3	To set the baud rate of the output of the COM, the valid value in bps value is: 115200,230400,460800,921600,1500000 If value is other values, the default value is 115200bps The baud rate Parameter takes effect only after the system restarts. Procedure for setting the power-off: Set the baud rate, save Parameter to the flash, and reset the software
14	<value>	21	Set the periodic AHRS data output frequency. The unit Hz value is 1,10,50,100,200,500 Recommended mapping between output frequency and serial (port 不要?) baud rate 500Hz: 460800bps 200Hz: 460800bps 250Hz: 460800bps 100Hz: 115,200 BPS

14	<value>	31	Internal filter configuration, defined as SPI Accelerometer and gyroscope filter configuration, default 0xBB, that is, 47Hz
14	<value>	4	Set the orientation of the IMU coordinate system. The value ranges from 101 to 124. See Table 25 for the corresponding relation of the orientation of the coordinate system

Note 1: Please note that all values in this table are in decimal

Note 2: Corresponding commands can be generated and sent using the Upper computer software command generator function. For the usage method, see the Upper computer software Usage section of this manual

For example, to enable AHRS output:

Enter 3 in CMD ID and 1 in Parameter 1. The generated hexadecimal array can be filled into the COM assistant or program array and sent to the IMU.

7.7 Command Mode Output — User Command Response

Table 25 Setting Parameter COM response data format

	Frame header	Frame header	ID	length	ACK	Param3	Frame trailer
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x753D	0x0004	0x7534	Parameter index	crc32

Table 26 Reserved Parameter COM response data format

	Frame Headers	Frame Headers	ID	length	ACK	result	Frame Tail
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x753D	0x0004	0x0005	0x01	crc32

Table 27 Data format of COM user command response

	Frame header	Frame Headers	ID	length	command	result	Frame Tail
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x0064	0x0004	Command ID	0x01	crc32

Example: Set the baud rate of the serial port output to 115200

Data input: 55, AA, 0 e, 00,18,00,00,00, E1, 47,00,00,00,00,03,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,56,2 B, 4 d, 93

Response data: AA 55 3D 75 04 00 34 75 03 00 A7 98 2A 54

Set the periodic AHRS data output frequency to 100hz

Input data: 55 AA 0E 00 18 00 00 00 00 C8 42 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0A 2B 2C 8D

Response data: AA 55 3D 75 04 00 34 75 15 00 70 2D B2 48

Save the current Parameter to FLASH

Enter data: 55 AA 05 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 C9 2F E6 32

Response data: AA 55 3D 75 04 00 05 00 01 00 5A CF B1 7C

Set the output mode to AHRS data flow

Input data: 55 AA 03 00 18 00 00 00 00 80 3F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 52 D8 8E E8

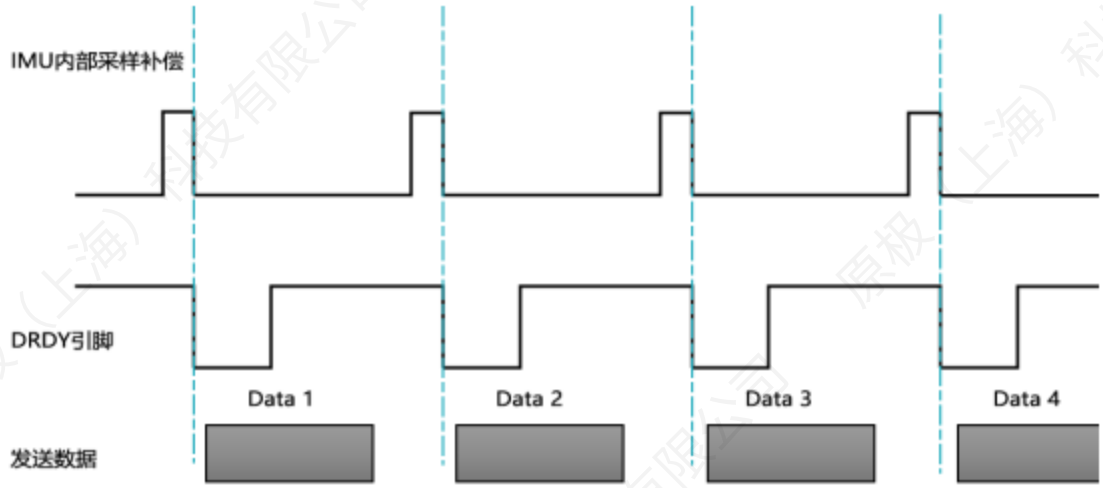
Response data: AA 55 64 00 04 00 03 00 01 00 E7 87 E3 AD

7.8 DRDY

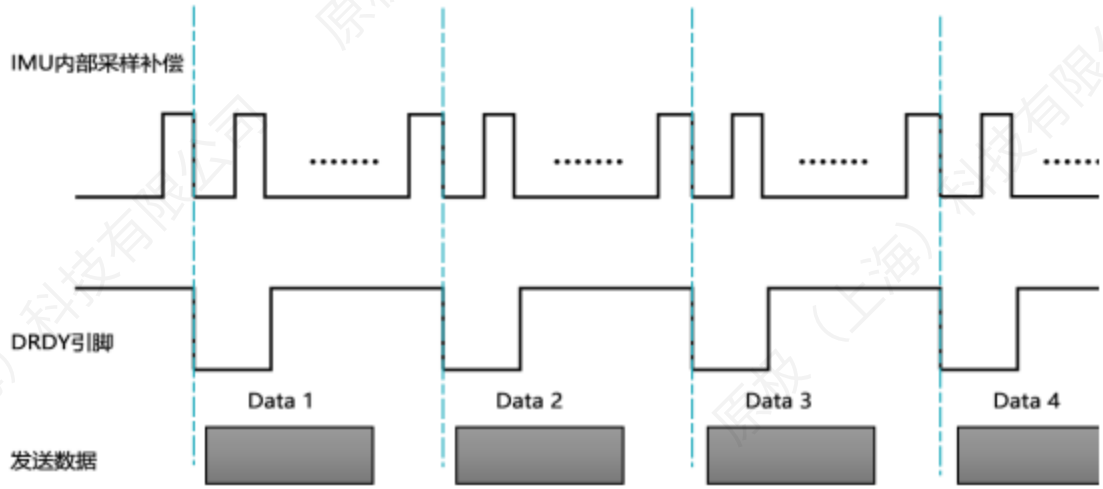
DRDY Pin output serves two purposes:

1. to provide a clock synchronization signal from inside the IMU;

2. Provide a signal to signal the start of transmitting data frames.



When the internal sampling frequency of the IMU (maximum ODR) is consistent with the serial output frequency (current ODR), the DRDY pin will be pulled down immediately after the completion of Imu data sampling compensation, at which time the data frame will be sent from the serial port, and the DRDY internal sampling frequency will be pulled up again in the next cycle.



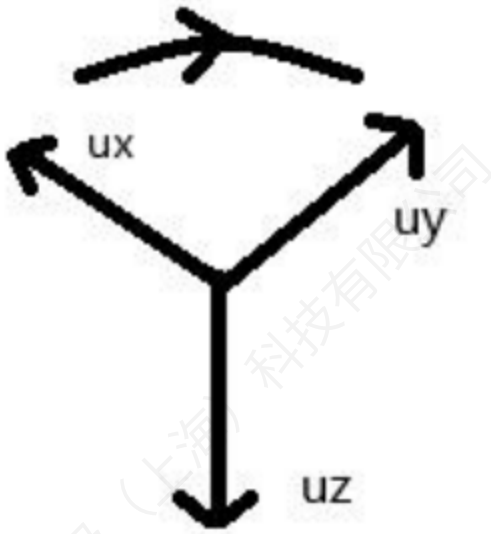
When the serial output frequency is less than the IMU internal sampling frequency, after the imu data sampling compensation is completed, it is determined whether DRDY pin cell is immediately pulled down according to the value youdaoplaceholder3 (maximum ODR/ current ODR). After the DRDY is pulled down,

the data frame will be sent from the COM, and the DRDY Pin will be pulled up again in the next IMU sampling period.

7.9 Coordinate system setup function

Set the firmware coordinate system and display the corresponding firmware design coordinate system in the Upper computer software

Figure 8 Original firmware coordinate system



According to the above rule, after x and y axes are determined, z axis is determined. The Z axis is perpendicular to the plane from the X to the Y axis.

There are a total of 24 orientations for the X/Y/Z axis, as shown in the table below:

The orientation of the coordinate system in Table 28 corresponds to the table

Orientation (value)	XAxis	YAXis	ZAxis	Instructions
101	+Ux	+Uy	+Uz	Default orientation
102	-Ux	-Uy	+Uz	
103	-Uy	+Ux	+Uz	
104	+Uy	-Ux	+Uz	

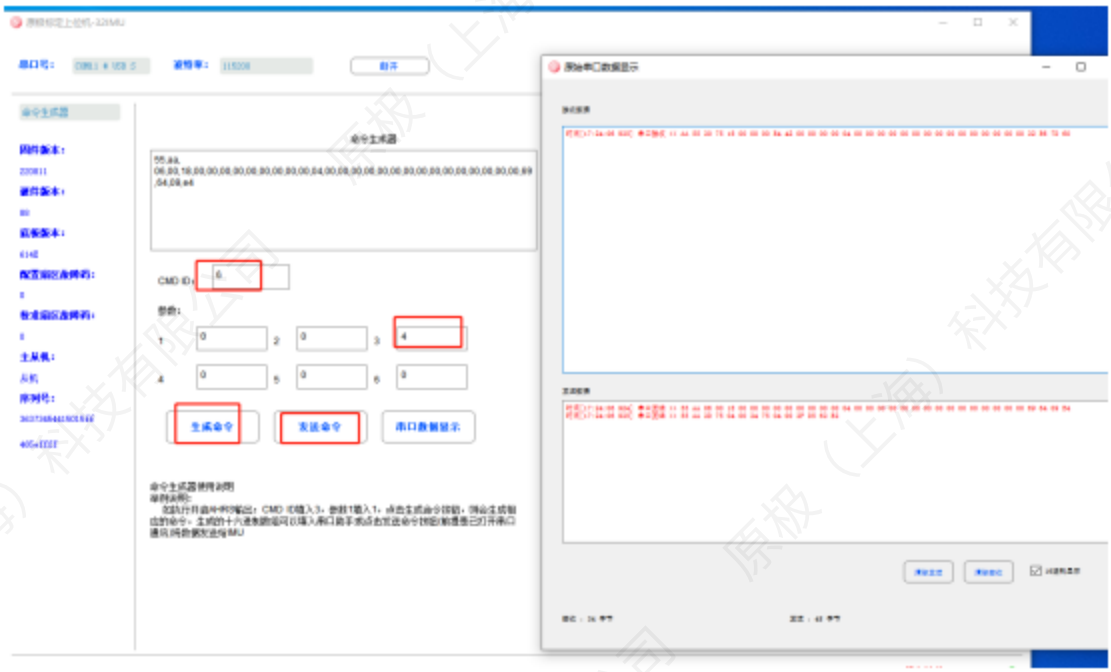
105	-Ux	+Uy	-Uz	
106	+Ux	-Uy	-Uz	
107	+Uy	+Ux	-Uz	
108	-Uy	-Ux	-Uz	
109	-Uz	+Uy	+Ux	
110	+Uz	-Uy	+Ux	
111	+Uy	+Uz	+Ux	
112	-Uy	-Uz	+Ux	
113	+Uz	+Uy	-Ux	
114	-Uz	-Uy	-Ux	
115	-Uy	+Uz	-Ux	
116	+Uy	-Uz	-Ux	
117	-Ux	+Uz	+Uy	
118	+Ux	-Uz	+Uy	
119	+Uz	+Ux	+Uy	
120	-Uz	-Ux	+Uy	
121	+Ux	+Uz	-Uy	
122	-Ux	-Uz	-Uy	
123	-Uz	+Ux	-Uy	
124	+Uz	-Ux	-Uy	

How to change the coordinate system to 102 orientation:

CMD ID fill in 14, parameter 1 fill in 102, parameter 3 fill in 4, and the resulting hexadecimal array can be filled into the serial assistant or program array and sent to the IMU.

How to read the coordinate system orientation:

CMD ID fill in 06, parameter 3 fill in 4, the resulting hexadecimal array can be filled into the serial assistant or program array to send to the IMU.



Example: Set the coordinate system to face 115

Data input: 55, aa, 0 e, 00,18,00,00,00, e6,
42,00,00,00,00,04,00,00,00,00,00,00,00,00,00,00,00, 00,00,00,00,46,6 a, 4 e,
86

Response data: AA 55 3D 75 04 00 34 75 04 00 60 0E 6B 1B

Refer to Table 22 to parse the parameter index as 04, and the setting is successful

Read the coordinate system:

Input data: 55 AA 06 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 04 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
69 64 09 E4

Response data: AA 55 30 75 18 00 00 00 00 E6 42 00 00 00 00 00 00 00 00 04
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 B2 2F 2D 4E

According to Table 16 and Table 17, the parsing results in 115 for parameter 1 (float) and 04 for parameter 3. That is, the coordinate system is 115 orientation

7.10 Common AT instruction

7.10.1 Stop the current data stream output

Instruction: AT+SETNO\r\n

Answer: OK\r\n

You can stop the current data flow (without changing the Parameter of the data flow). If the response is OK, the next operation can be performed.

If there is no response, you can continue to send AT+SETNO\r\n command until the response is OK.

7.10.2 Querying the version number

Instruction: AT+VERSION\r\n

Answer: SW_VERSION Firmware version
HW_VERSION Hardware version
BOARD_VERSION Backboard version

7.10.3 Querying User Parameter

Instruction: AT+CONFIG\r\n
Reply: BAUD_RATE Baud rate of
the COM ORIENT current coordinate system
IMU_ODR Output frequency of the current IMU
STREAM_MODE1 Data flow mode of COM 1
STREAM_MODE2 Data flow mode of COM 2
STREAM_MODE3 Data flow mode of COM 3
LP_CONFIG_REG Filtering of the current IMU

7.10.4 Setting and Querying the ODR

Example: Set the output frequency ODR to 50hz
Command: AT+SET_ODR=50
Answer: IMU_ODR:50
Query the ODR command of the IMU

: AT+GET_ODR

Answer: IMU_ODR:

7.10.5 Setting and querying the coordinate system

Example: Set the IMU coordinate system to top right front

Instruction: AT+SET_ORIENT=101\r\n

Answer: orientation:101

Query the current IMU coordinate system

Instruction: AT+GET_ORIENT\r\n

Answer: orientation:

7.10.6 Set and query baud rate

For example, set the baud rate of the IMU to 115200

Instruction: AT+SET_BAUD=115200\r\n

Answer: OK

Query the current baud rate of IMU

Instruction: AT+GET_BAUD\r\n

Answer: BAUD_RATE:

7.10.7 Setting and querying filters

Example: Set the filter of the IMU to 20hz

Instruction: AT+SET_LPF=20\r\n

Answer: LP_CONFIG_REG:20

Query the IMU current filter

Instruction: AT+GET_LPF\r\n

Answer: LP_CONFIG_REG:

7.10.8 Save parameters

Instruction: AT+SAVE\r\n

Answer: OK

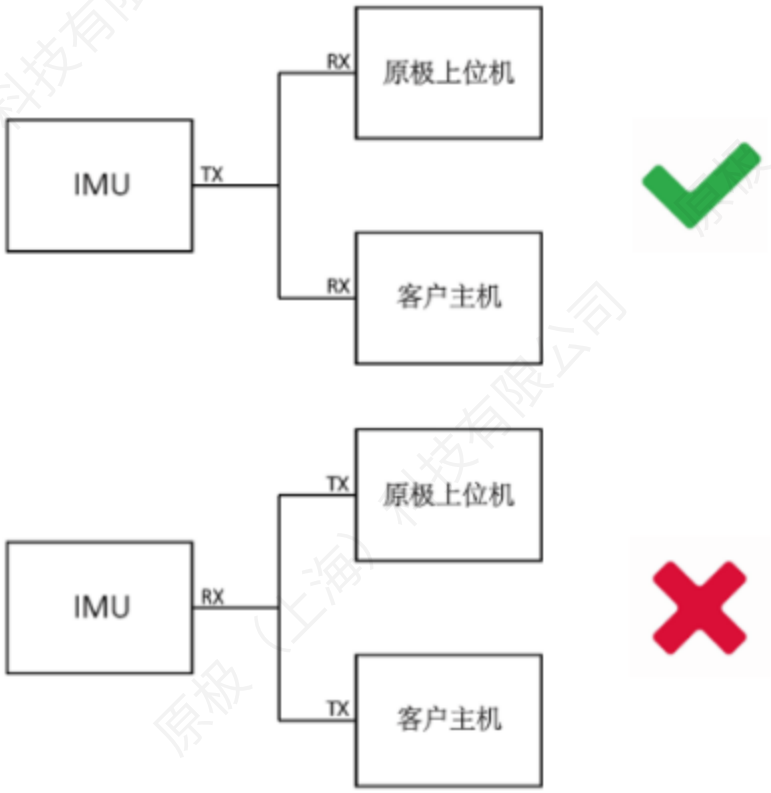
7.11 Serial Port Connection FAQs

1) The RX of the IMU cannot connect to 2 host TXS

The RX of the COM cannot be connected to two TX at the same time. Therefore, if the Forsense upper machine needs to be connected, it needs to disconnect the communication with the COM of the user's host. Otherwise, the upper computer cell can only receive data and cannot send commands to the IMU.

As shown in the following picture:

Figure 9 COM connection



注：IMU TX 可接多路 RX，RX 不可接多路 TX；
IMU串口不可同时连接客户主机和原极上位机；
IMU可以预留另外一路串口专门连接原极上位机。

2) The version number cannot be obtained

You are advised to use the COM of the FT232 chip. CH340 and PL2303 data cables may lose packets when the baud rate is high (>115200bps)

It is recommended that COM be connected directly, and it is not recommended to be connected in series. If the interface of RS422 is connected to the computer, directly use RS422 to USB cable, and do not use RS422 to RS232+RS232Z to USB cable in series.

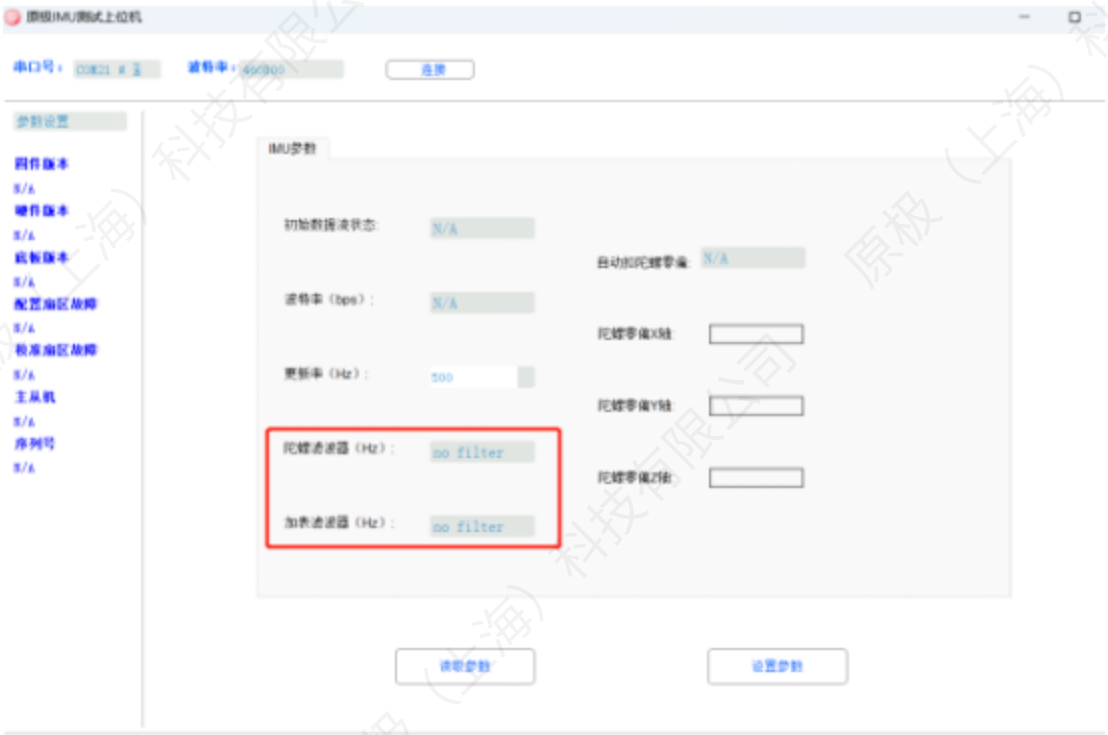
3) Upper computer software curve display lag

If it is an FT232 data line, use the system administrator to open the Upper computer software and automatically configure the COM delay

Manually configure COM delay in Device Manager.

8. Precautions for post-processing use

1. Confirm whether all filters are no filter (screenshots are retained), and the Update Rate is generally SET to 500hz, which can be confirmed by the Upper computer software or queried by command. For specific commands, refer to the 7.6 command mode set instruction or the common AT instruction in chapter 7.10

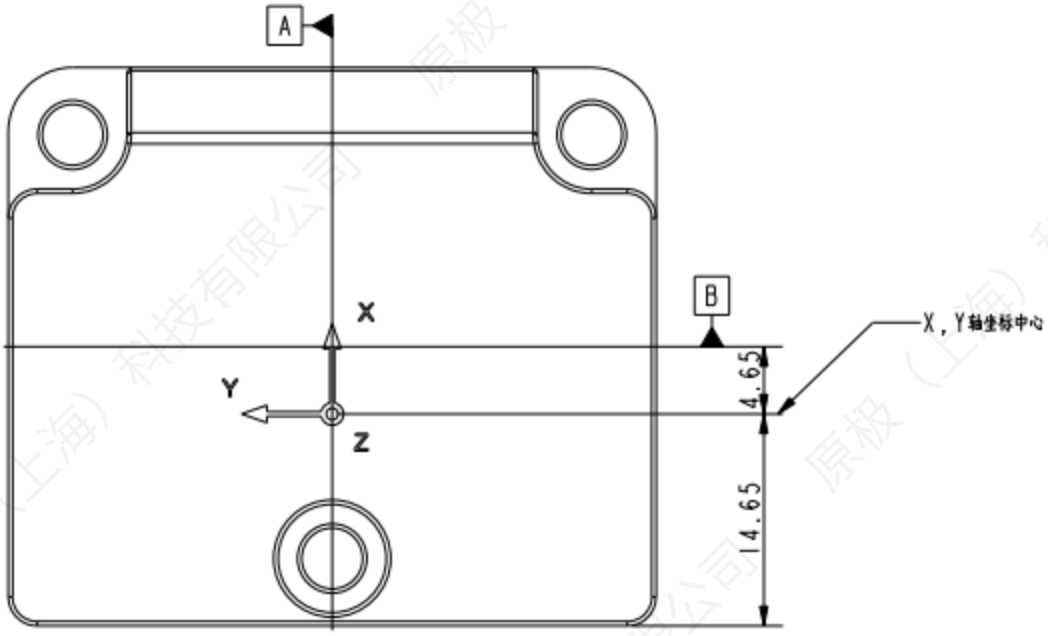


2. P8 pro data output has 7.2ms delay, which needs to be subtracted when stamping!!!

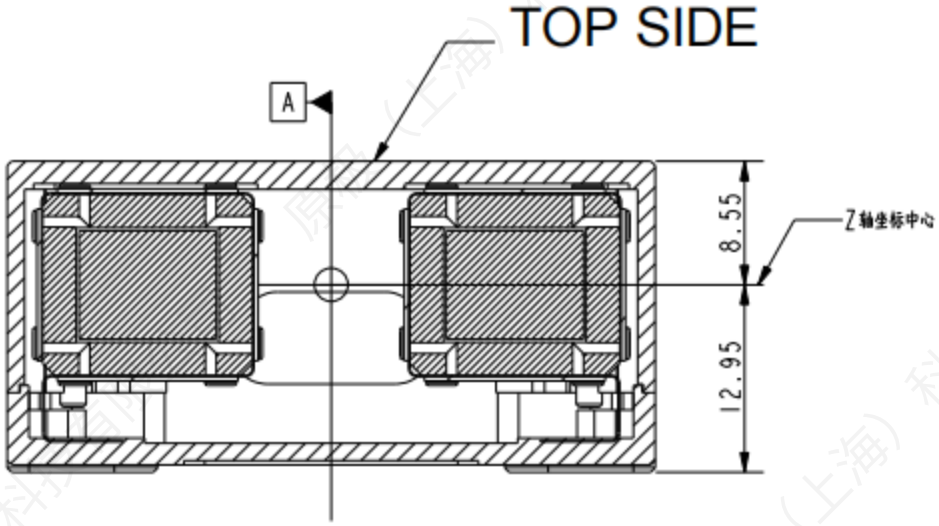
3, the rod arm configuration

Note that the physical center point of the P8 pro IMU is shown in the figure below, and attention should be paid to the configuration of the rod arm

TOP SIDE



TOP SIDE



4. in terms of data processing

① Use the following P8 pro Parameter

Name: P8pro Source: User created/altered

Initial Standard Deviation Values

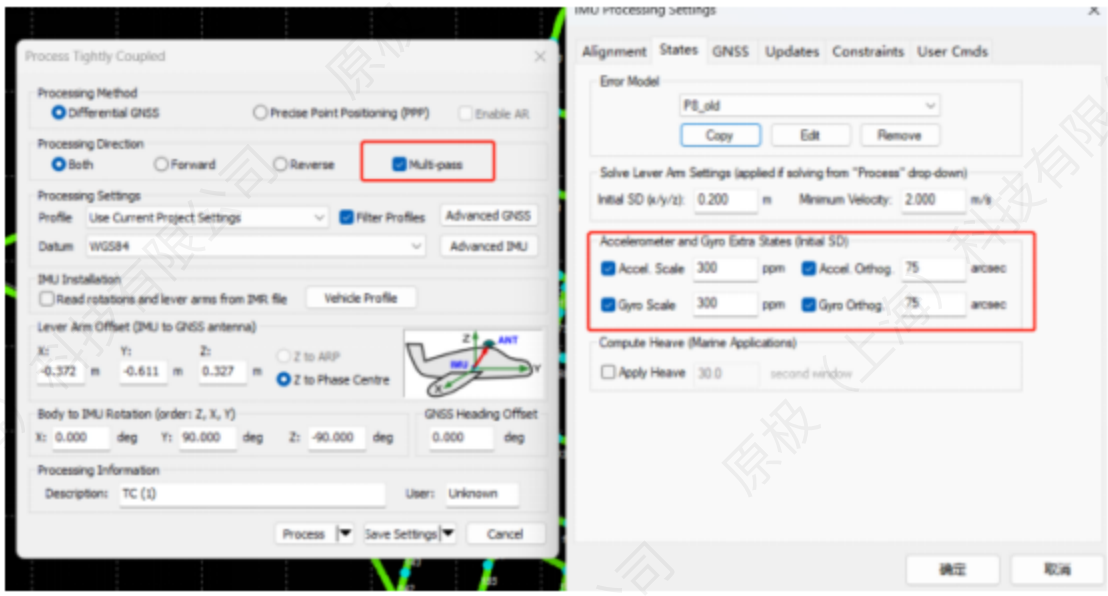
	X-Axis	Y-Axis	Z-Axis	
Accel Bias:	1.00000e-02	1.00000e-02	1.00000e-02	metres/s^2
Gyro Drift:	1.00000e-01	1.00000e-01	1.00000e-01	deg/s

Spectral Densities

	X-Axis	Y-Axis	Z-Axis	
ARW:	6.00000e-02	6.00000e-02	6.00000e-02	deg/sqrt(s)
Accel Bias:	3.16406e-09	3.16406e-09	3.16406e-09	m/s^2/sqrt(s)
Gyro Drift:	3.11000e-07	3.11000e-07	3.11000e-07	deg/s/sqrt(s)
VRW:	9.68722e-06	9.68722e-06	9.68722e-06	m/s/sqrt(s)
Position:	1.00000e-04	1.00000e-04	1.00000e-04	m/sqrt(s)

OK Cancel

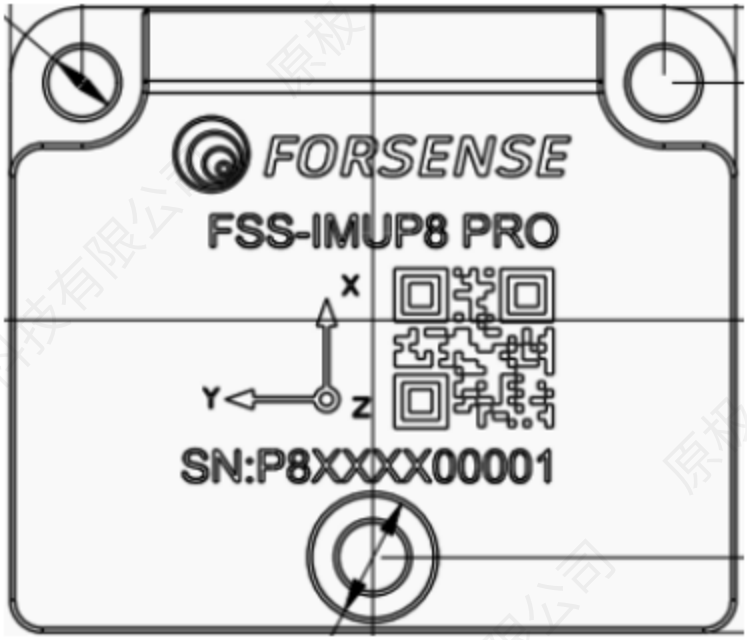
② Select the Settings shown in the following figure when the Internet Explorer performs processing



5. Recommended flight mode

Stand still before takeoff, circle back and forth eight times, stand still after landing on the ground

9. Definition of coordinate system



This product coordinate system uses the front - right - down (FRD) coordinate system. Euler Angle range is as follows:

Rotation around the Z axis: course Angle Yaw range: 0° ~360°;

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

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

Roll, pitch, and course Angle diagram is as follows:

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

10. CRC table lookup method calculation

It is recommended to refer directly to the example code.

Note 1: Data is transmitted in small-endian format, with low bytes first and high bytes last

Note 2: The initial value of crc32 is 1, and CRC calculations do not include all the data in this frame itself

```
C++
  static  const  uint32_t  crc32_tab [ ]  =  {
  0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419, None 706Af48F
  ,0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4, 0xe0d5e91e, 0x97d2d988
  ,0x09b64c2b, 0x7eb17cbd, 0xe7b82d07, 0x90bf1d91, 0x1db71064, 0x6ab020f2
  ,0xf3b97148, 0x84be41de, 0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7
  ,0x136c9856, 0x646ba8c0, 0xfd62f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9
  ,0xfa0f3d63, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd56041e4, 0xa2677172
  ,0x3c03e4d1, 0x4b04d447, 0xd20d85fd, 0xa50ab56b, 0x35b5a8fa, 0x42b2986c
  ,0xdbbbc9d6, 0xacbcf940, 0x32d86ce3, 0x45df5c75, 0xdcd60dcf, 0xabd13d59
  ,0x26d930ac, 0x51de003a, 0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423
  ,0xcfba9599, 0xb8bda50f, 0x2802b89e, 0x5f058808, 0xc60cd9b2, 0xb10be924
  ,0x2f6f7c87, 0x58684c11, 0xc1611dab, 0xb6662d3d, 0x76dc4190, 0x01db7106
  ,0x98d220bc, 0xefd5102a, 0x71b18589, 0x06b6b51f, 0x9fbfe4a5, 0xe8b8d433
  ,0x7807c9a2, 0x0f00f934, 0x9609a88e, 0xe10e9818, 0x7f6a0dbb,  0x086d3d2d
  ,0x91646c97,  0xe6635c01,  0x6b6b51f4,  0x1c6c6162,  0x856530d8,
0xf262004e
  ,0x6c0695ed,  0x1b01a57b, 0x8208f4c1, 0xf50fc457, 0x65b0d9c6, 0x12b7e950
  ,0x8bbeb8ea, 0xfcb9887c, 0x62dd1ddf, 0x15da2d49, 0x8cd37cf3, 0xfbd44c65
  ,0x4db26158, 0x3ab551ce, 0xa3bc0074, 0xd4bb30e2, 0x4adfa541, 0x3dd895d7
  ,0xa4d1c46d, 0xd3d6f4fb, 0x4369e96a, 0x346ed9fc, 0xad678846, 0xda60b8d0
  ,0x44042d73, 0x33031de5, 0xaa0a4c5f, 0xdd0d7cc9, 0x5005713c,  0x270241aa
  ,0xbe0b1010,  0xc90c2086,  0x5768b525,  0x206f85b3,  0xb966d409,
0xce61e49f
  ,0x5edef90e,  0x29d9c998, 0xb0d09822, 0xc7d7a8b4, 0x59b33d17, 0x2eb40d81
  ,0xb7bd5c3b, 0xc0ba6cad, 0xedb88320, 0x9abfb3b6, 0x03b6e20c, 0x74b1d29a
  ,0xead54739, 0x9dd277af, 0x04db2615, 0x73dc1683, 0xe3630b12, 0x94643b84
  ,0x0d6d6a3e, 0x7a6a5aa8, 0xe40ecf0b, 0x9309ff9d, 0x0a00ae27, 0x7d079eb1
  ,0xf00f9344, 0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d,  0x806567cb
```

```
  ,0x196c3671,  0x6e6b06e7,  0xfed41b76,  0x89d32be0,  0x10da7a5a,
0x67dd4acc
  ,0xf9b9df6f,  0x8ebeeff9,  0x17b7be43,  0x60b08ed5,  0xd6d6a3e8,
0xa1d1937e
  ,0x38d8c2c4,  0x4fdff252,  0xd1bb67f1,  0xa6bc5767,  0x3fb506dd,
0x48b2364b
  ,0xd80d2bda, 0xaf0a1b4c, 0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55
  ,0x316e8eef, 0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236
  ,0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe, 0xb2bd0b28
  ,0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31, 0x2cd99e8b, 0x5bdeae1d
  ,0x9b64c2b0, 0xec63f226,  0x756aa39c,  0x026d930a,  0x9c0906a9,
0xeb0e363f
  ,0x72076785,  0x05005713,  0x95bf4a82,  0xe2b87a14,  0x7bb12bae,
0x0cb61b38,0x92d28e9b
  , 0xe5d5be0d, 0x7cdcefb7, 0x0bdbdf21, 0x86d3d2d4, 0xf1d4e242,0x68ddb3f8
  , 0x1fda836e, 0x81be16cd, 0xf6b9265b, 0x6fb077e1, 0x18b74777,0x88085ae6
  , 0xff0f6a70, 0x66063bca, 0x11010b5c, 0x8f659eff, 0xf862ae69,0x616bffd3
  , 0x166ccf45, 0xa00ae278, 0xd70dd2ee, 0x4e048354, 0x3903b3c2
  ,0xa7672661, 0xd06016f7,  0x4969474d,  0x3e6e77db,  0xaed16a4a,
0xd9d65adc,0x40df0b66
  ,  0x37d83bf0,  0xa9bcae53,  0xdebb9ec5,  0x47b2cf7f,
0x30b5ffe9,0xbdbdf21c
  , 0xcabac28a, 0x53b39330, 0x24b4a3a6, 0xbad03605, 0xcdd70693,0x54de5729
  , 0x23d967bf, 0xb3667a2e, 0xc4614ab8, 0x5d681b02, 0x2a6f2b94,0xb40bbe37
  , 0xc30c8ea1, 0x5a05df1b,  0x2d02ef8d
  ,}
   uint32_t  crc_crc32 (uint32_t  crc,  const  uint8_t  *buf,  uint32_t
size ) {for   (uint32_t
    i=0;  i<size ;  i++)  {crc
  =  crc32_tab [ (crc  ^  buf [i ] )  &  0xff]  ^  (crc  >>  8 ) ;
  }
  return crc;
  }
```

11 Use examples

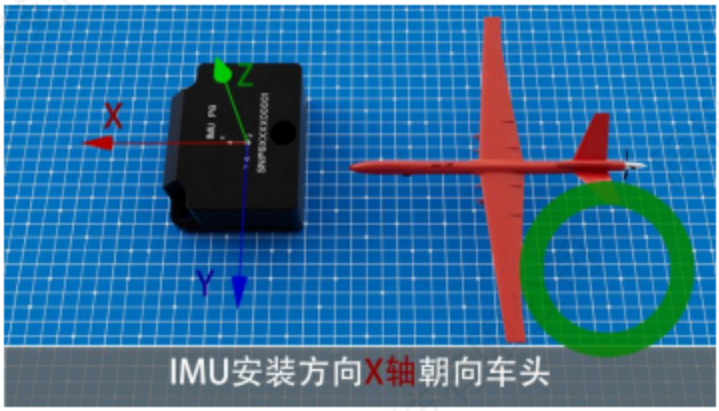
11.1 Device Installation

1. The module should be firmly fixed on a rigid plane and avoid being installed in a position with large vibration.
2. The module should be installed in the same direction as the front.

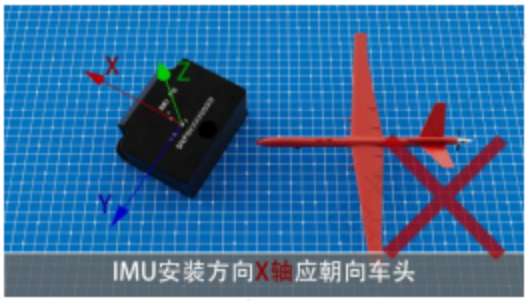
The correct installation diagram is as follows

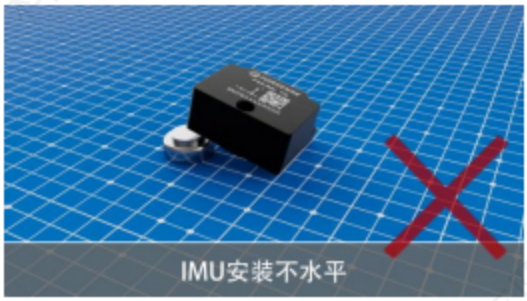
The X axis faces the front of the car

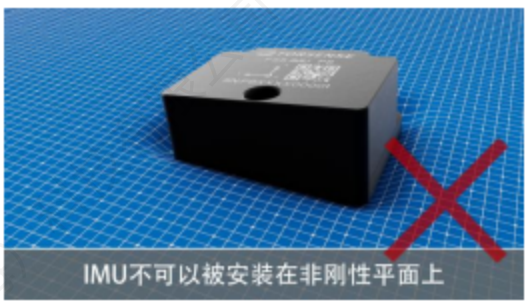
Figure 10 Diagram of proper installation

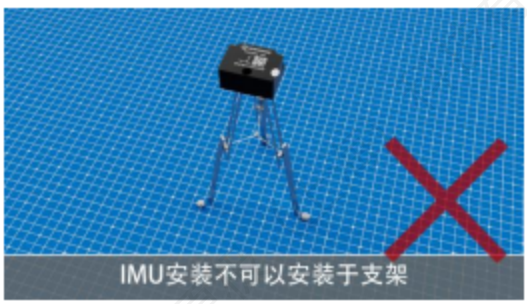


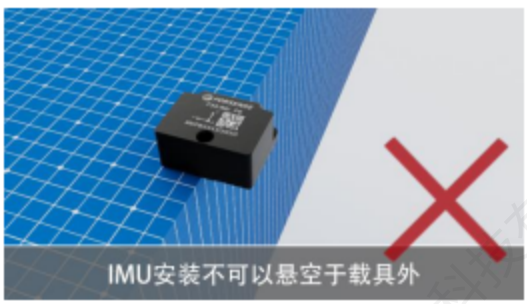
The following installation methods are incorrect installation











12. Select accessories

422 COM cable (the Forsense of the harness has been modified with 5V power supply)

422 and P8 signal conversion cables

13. Update the record

Versions	Dates	Status/Comments
Version 1.0	2023.10.07	First Issue
Version 1.1	2023.12.14	Add attachments
Version 1.2	2024.03.26	Add common AT instructions
Version 1.3	2024.12.02	Added AHRS-Q data stream