Tactical MEMS 6 degrees Of freedom inertial sensor

FSS-IMU614E-Q Product manual

Features

Tactical grade MEMS gyroscope

- 5.0°/hr zero bias instability
- 0.6 Angle random walk°/$\sqrt{hr}$

Tactical grade MEMS accelerometer

- 40μg zero-bias instability
- 0.09 Velocity random walkm/s/$\sqrt{hr}$

Independent turntable calibration

- Independent calibration of each module: sensitivity, zero bias, non-orthogonal error
- -40 ° C to 85 ° C temperature compensation

High strength 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℃ ~ 85℃
- 100% magnetic shielding

Real-time and flexible digital interface, small size

- Configurable output sampling rate up to 1kHz
- Support serial port, I2C, SPI multiple interfaces
- 14.7*17*3.2mm, weight only 2g

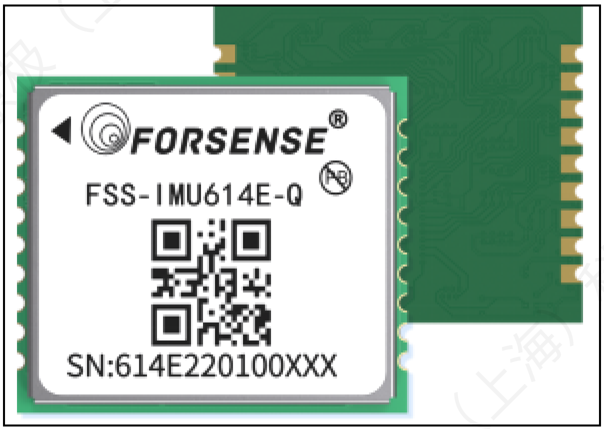
Product Overview

FSS-IMU614E-Q is a 6-DOF MEMS inertial sensor module built by Yuanji Technology. Three-axis gyroscope and acceleration information are available as standard. High precision, high resolution, can capture subtle vibration and tilt. All modules are turntable calibrated before leaving the factory, so that each module can be stable under various extreme conditions, while ensuring a high degree of consistency in performance across all products.

Application areas

- All kinds of robots: including AGV, service robot, lawn mower, pool robot, etc

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



Contents

1. Performance parameters

1.1 Key indicators of Gyroscope

Table 1 Key indicators of Gyroscope

Parameters	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			＋500		°/s
Bias instability instability	@25, Allan Variance, 1σ		5		°/hr
Bias stability	National military standard, 10s smooth		16		°/hr
Bias Repeatability	National Army mark		25		°/hr
Resolution			0.0153		°/s
Misalignment			0.05		deg
Internal low-pass cutoff frequency	Software adjustable		47		Hz
ODR			1000		Hz
Measuring delay			5		ms
All temperature range Bias instability change	-40 ℃ ~85 ℃, ≤1℃/ min@1σ		0.05		°/s
Random Walk	@25, ALLAN variance, 1σ		X:0.85 YZ:0.6		°/√hr
Calibration coefficient error	@25, 1σ		3		‰
Calibration coefficient nonlinearity			200		ppm

Note 1: IEEE standard. Allan variance curve given at static 25 ° C environment

Note 1σ change in total temperature with zero deviation at 2:1 ° C/min

1.2 Key indicators of accelerometer

Table 2 Key indicators of accelerometer

Parameter	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			Plus or minus 6		g
Zero bias instability	@25 ALLAN variance, 1 sigma		40		Mu g
Zero bias stability	National military standard, 10s smooth		85		Mu g
Zero bias repeatability	National Army mark		0.15		mg
Resolution			0.183		mg
Non-orthogonal between axes			0.05		deg
Internal low-pass cutoff frequency	Software adjustable		47		Hz
ODR			1000		Hz
Measuring delay			5		ms
Full temperature range zero deviation variation	- 40 ℃ ~ 85 ℃, ≤1℃/ min@1σ		2		mg
Random Walk	@25, ALLAN variance, 1 σ		0.09		m/s/√hr
Calibration coefficient error	@25, 1σ		0.5		‰
Scale coefficient nonlinearity	±1g		300		ppm

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

Note the zero deviation of the total temperature changes by 1σ at 2:1 ℃/ min

FIG. 1 ALLAN variance typical curve of gyroscope

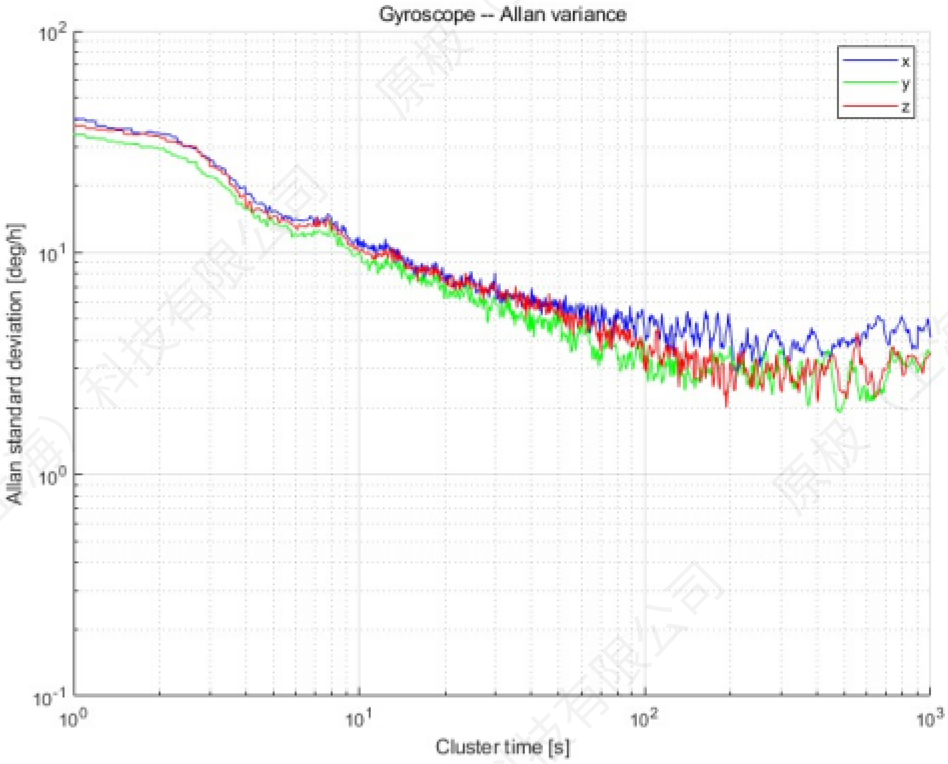
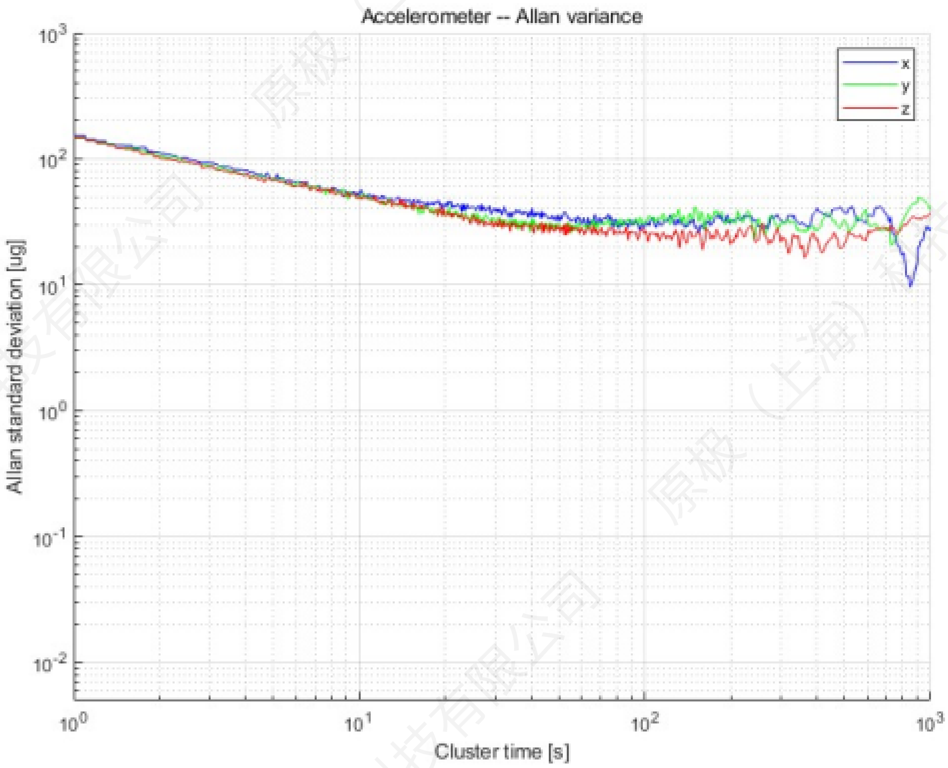
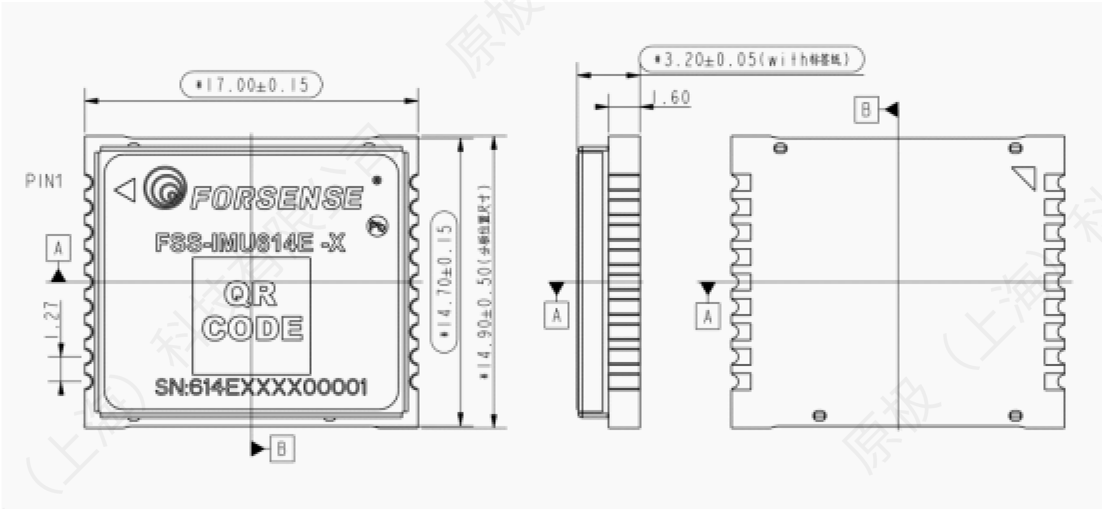


FIG. 2 Typical curve of ALLAN variance for accelerometer

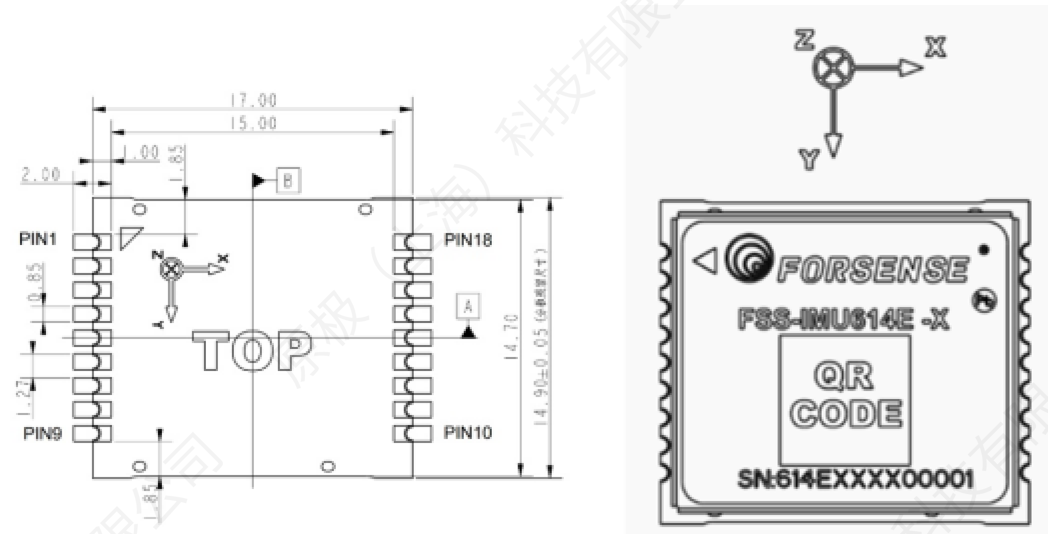


2. External structure

Figure 3 Outline structure and recommended pad size (unit: mm)



Dimensions of Outline structure



Recommended pad size

3 Electrical characteristics

3.1 Maximum tolerance value

Table 3 Maximum absolute rating

Parameter	Symbols	Range	Units
Voltage for Circuit to Circuit (VCC)	VCC	-0.3 to 4.0	V
Power source	GND	-	-
Input pin voltage	Vin	-0.3 to VCC+0.2	V
Use temperature	Tot	-40 to 85	℃
Storage temperature	Tstg	-40 to 85	℃

3.2 Working Conditions

Table 4 Working conditions

Parameter	Symbols	Minimum value	Typical value	Maximum value	Units
Voltage for Circuit to Circuit (VCC)	VCC	3.2	3.3	3.4	V
VCC maximum ripple	Vrpp		+ 40		mV
Power Consumption	P		0.08		W
Service temperature	T	-40		85	℃
Storage temperature	T	-40		85	℃

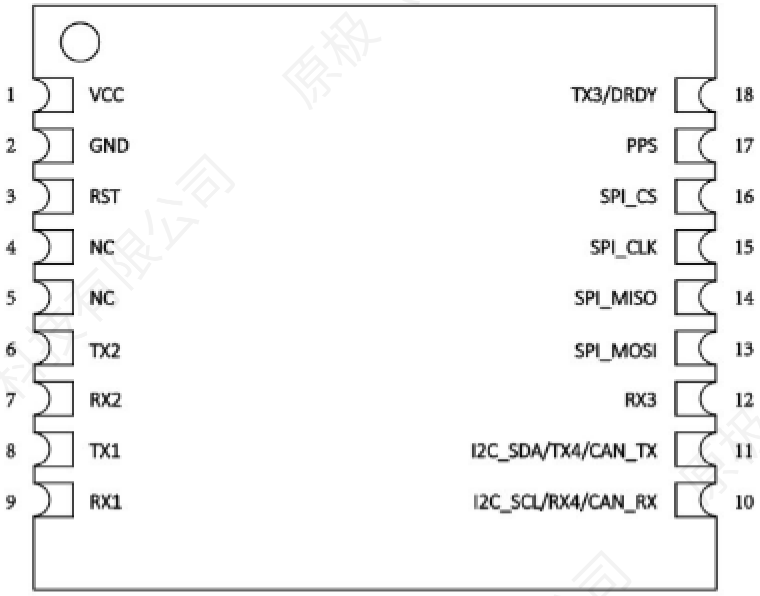
3.3 I/O Threshold Characteristics

Table 5 I/O Threshold Characteristics

Parameters	Symbols	Minimum value	Typical value	Maximum value	Units
Input pin low	Vin_low	0		VCC * 0.2	V
Input pin high level	Vin_high	VCC * 0.7		VCC + 0.2	V
Output pin low	Vout_low	0		0.45	V
Output pin high	Vout_high	VCC - 0.45 -		VCC	V

4 Pin definition

Figure 4 Pin schematic



IMU614E-X Pin Layout (Top View)

Table 6 Pin definitions

Pin number	Pin name	Pin description
1	VCC	Power input, +3.3V input, 40mA, ripple not greater than ±40mV
2	GND	Power ground
3	RST 1	External hardware reset input, internal pull-up (for SPI mode)
4	NC	Connectionless
5	NC	Connectionless
6	TX2	Receive asynchronous data output
7	RX2	Receive asynchronous data inputs
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 / Features / Description

		1	CAN_RX	CAN receive pins; And 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	Features	Description
		1	CAN_TX	CAN send pins; Read data from the CAN controller to the 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 entry		
14	SPI_MISO	SPI serial data output		
15	SPI_CLK	SPI Serial clock		
16	SPI_CS	SPI slice selection		
17	PPS	External synchronous sampling trigger signal; (Access RTK second pulse pin)		
18	TX3/DRDY	Receive asynchronous Data output/available for Data Ready		

Note 1: Use /RST to reset the IMU hardware once during host initialization

For information about the hardware design of the module, see the document FSS-IMU614E-XX Hardware Design Manual.

5 Recommend the welding furnace temperature curve

Figure 5 Welding furnace temperature curve

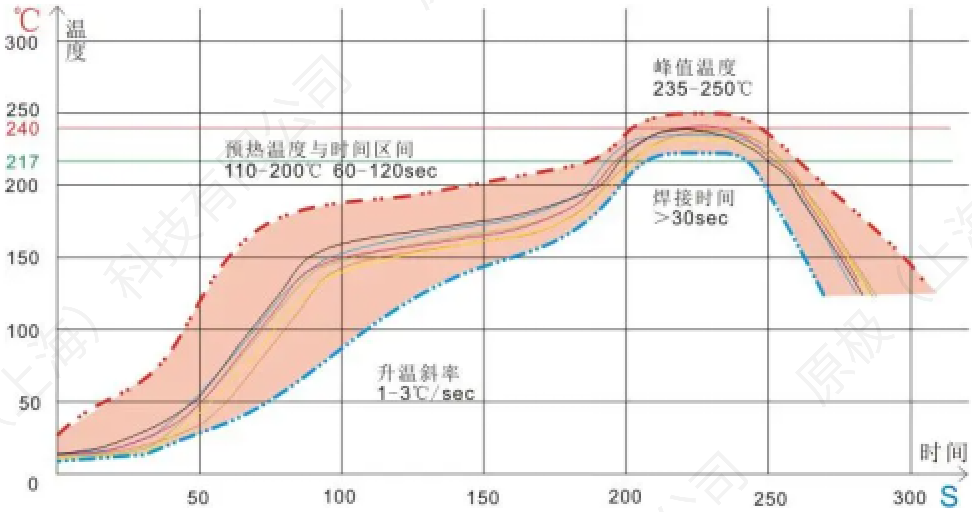


Table 7 Temperature setting mode

Items	Minimum Boundaries	Maximum limit	Units
Maximum temperature rise slope (target =0.8) (Time distance to calculate slope =60 seconds)	1	3	Degrees per second
Maximum temperature drop slope (Time distance to calculate slope =60 seconds)	-3	-1	Degrees per second
Preheat temperature and time interval	60	120	seconds
Reflux time (period over 217 ° C)	40	70	seconds
Maximum temperature	235	250	Degrees Celsius
Maximum number of reflow		1	time

For more SMT related information about the module, please see the document "Primary -LCC Module _SMT Application Guide".

Note:

1. Module welding reflow, it is recommended to use eight temperature zone and

above reflow welding equipment;

2. Because the module is a high-precision sensor product, it is more sensitive to any deformation:

- If the PCB board thickness is less than 1.0mm, it is recommended to make reflow loading tools to prevent the PCB board from deforming at high temperature, affecting the coplanarity of welding.
- It is recommended that customers choose high TG value board for PCB motherboard to avoid deformation of the motherboard due to high temperature reflux, resulting in warping, extrusion, air welding and poor tinning.

3. Due to the sensitive devices in the module, the maximum temperature of the reflow welding machine used by the customer should not exceed 260℃ (refers to the temperature at the top of the package measured on the surface of the package).

4. It is recommended to use lead-free solder paste, recommended solder paste brand model: Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5

5. Because there are sensitive devices in the module, the performance of the module should be avoided due to secondary reflux;

6. CD:

- Controlled cooling slope prevents negative welding effects (solder joints become more brittle) and mechanical stress within the product. Controlled cooling helps achieve bright welding surfaces, fine crystalline particles and low contact angles, avoiding warping of the shield cover due to rapid cooling changes.

7. Inspection of appearance:

- After the module is welded, X-ray and optical magnifying glass are used to inspect the welding quality. For details, please refer to IPC-A-610F related standards.

8. **When using electric soldering iron for welding, the temperature should be controlled at 260℃ ~ 290℃, the single welding time should not exceed 3s, and do anti-static treatment;**

6. ESD protection

Static electricity can lead to intermittent or permanent circuit damage, great harm to electronic products, most of the analysis is ESD damage;

Therefore, the module of electrostatic protection is particularly important, the production and transportation process needs to be strictly in accordance with electrostatic protection operations, must follow the following conditions:

- It is strictly forbidden to touch the module with bare hands, especially the pin position.
- SMT mounters, workbenches, soldering irons and other equipment should be grounded.
- Workers should wear a human anti-static wristband with a good grounding cable (cordless electrostatic wristbands are not allowed, and anti-static gloves are recommended).
- The packaging and PCB must be qualified anti-static material.

7 Communication protocols

7.1 Serial Communication Protocol

Examples of serial port protocols based on QT, ROS, and STM32:

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

Serial port communication has two modes: Stream Mode and Command Mode. After the IMU is powered on and initialized, the IMU enters the corresponding mode according to the mode value configured by the parameters.

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.

7.1.1 Parameters of serial port interface

Table 8 Serial port interface 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

7.1.2 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 lower byte of the serial communication frame ID
3		ID high byte	The upper byte of the serial communication frame ID
4	uint16	Data length low	The lowest byte of serial communication frame length, length is the number of bytes carried by payload, that is, n
5		High data length	The upper byte of serial communication frame length, 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

7.1.3 Data Flow frame — AHRS data

Table 10 AHRS data format of COM

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

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

Table 11 Serial port A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	Mu s	Time scale
4	pitch	float	°	Pitch Angle
8	roll	float	°	Roll Angle
12	yaw	float	°	Heading Angle
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 Serial port A1 gets AHRS data stream

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
Heading Angle	5C0FB243	356.12 °	imu chip temperature	D7A3EE41	29.83 ℃
X-axis acceleration	2506813D	0.063 g	crc32 Check	0CBF8480	2156183308

7.1.4 Command Mode GET Output -- System status

Table 13 COM system status data format

	Frame header	Frame Headers	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 14 Serial port S1 load data format

offset	Name	Data type	Description
0	Software_ver	uint32	Software version number
4	Hardware_ver	uint32	Hardware version number
8	rev	uint16	Reserved byte
10	sn0	uint32	First SN number
14	sn1	uint32	Second SN
18	sn2	uint32	Third SN
22	Board_version	uint32	Base Plate version number
26	Rev[16]	Uint8	All that follows is reserved bytes

Note 1: Reserved bytes vary based on the imu model. For example, 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 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).

7.1.5 Command mode GET output —— Read Parameter

Table 15 Input data formats of Parameter of the serial port

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

Table 16 Output data format of COM parameters

	Frame header	Frame header	ID	length	payload	Frame tail
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 17 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	Reserved. The default value is 0
20	Param6	Int32	Keep, default is 0

Table 18 Index table of COM P1 load parameters

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 24 Coordinate System Orientation correspondence table)	
8	X axis gyro Bias instability calibration results, GYRO_X_OFF	° /s
9	Y-axis gyro Bias instability calibration results, GYRO_Y_OFF	° /s
10	Z-axis gyro zero deviation calibration result, 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 00 31 2F A2 0A

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

7.1.6 Command mode SET instruction

Table 19 Syntax of the COM input command

	Frame header	Frame Headers	ID	length	payload	Frame end
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 20 Load data format of COM R1

offset	name	Data type	Description
0	Param1	float	Set Parameter
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 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 Stream Mode and enters the COMMAD mode
5	0	0	Save the current parameter to FLASH
6	0	<value>	Read the parameter, value is the index of the parameter to be read, that is, P1.index, see 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 After setting the baud rate parameter, you need to restart it for it to take effect. Procedure for setting the baud rate without power supply: Set the baud rate, save the parameter to the flash, and reset the software
14	<value>	21	Set the periodic AHRS data output frequency, common values in Hz value are: 1,10,50,100,200,500,1000 Recommended mapping between output frequency and COM baud rate 1000Hz: 921600bps 500Hz: 460,800bps 250Hz: 460800bps 200Hz: 460800bps 100Hz: 115,200 BPS
14	<value>	31	Internal filter configuration, defined as SPI accelerometer and gyro filter configuration, default 0xBB, i.e. 47Hz
14	<value>	4	Set the orientation of the IMU coordinate system. The value ranges from 101 to 124. See Table 24 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: The host command generator function can be used to generate the corresponding command to send

If run to open 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.

Figure 7

7.1.7 Command Mode Output — User command response

Table 22 Setting parameters COM response data format

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

Table 23 Reserved parameters Serial port response data format

	Frame header	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 24 Data format of COM user command response

	Frame Headers	Frame Headers	ID	length	command	result	Frame Tail
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
encoding	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 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 00 C9 2F E6 32

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

Set output mode to AHRS data stream

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

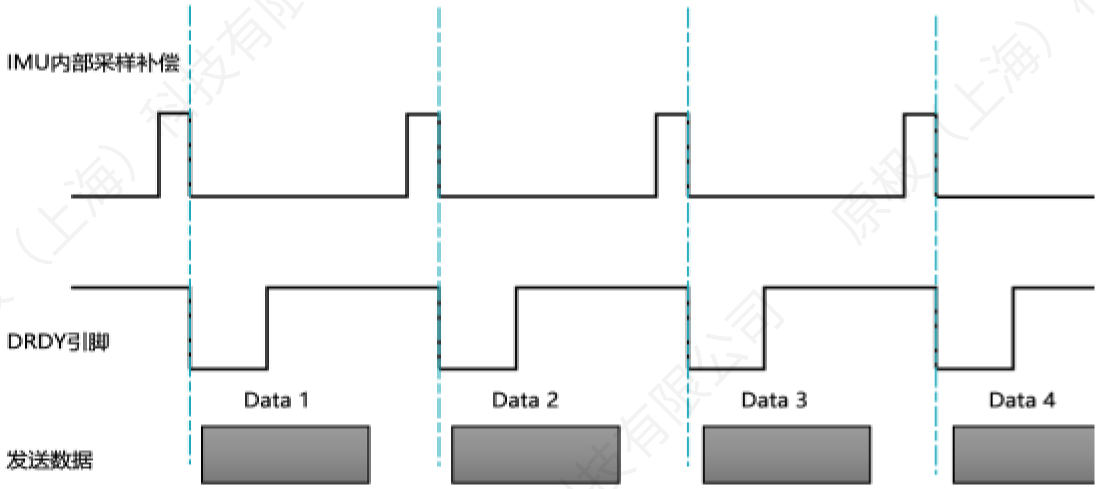
Response data: AA 55 64 00 04 00 03 00 01 00 E7 87 E3 AD

7.1.8 DRDY

DRDY pin output serves two purposes:

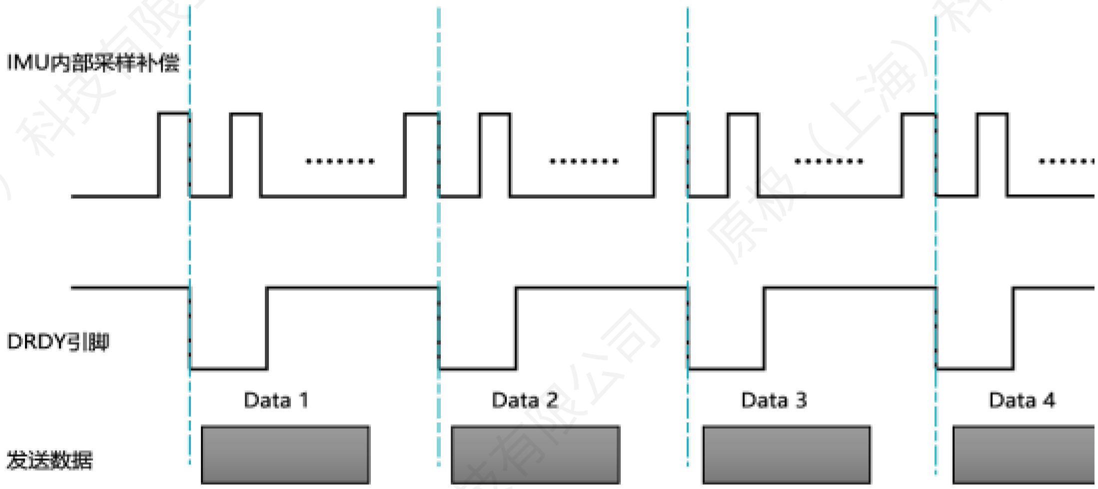
1. to provide a clock synchronization signal from inside the IMU;
2. Provide a signal to signal the start of transmitting data frames.

Figure 8 The internal sampling frequency is consistent with the serial output frequency



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

Figure 9 The serial port output frequency is less than the IMU internal sampling frequency

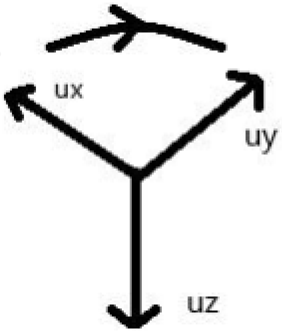


When the output frequency of the serial port is less than the internal sampling frequency of the IMU, determine whether the DRDY pin is immediately lowered according to the frequency divider value (maximum ODR/ current ODR) after the imu data sampling compensation is completed. After the DRDY is pulled down, the data frame will be sent from the serial port, and the DRDY pin will be pulled up again in the next IMU sampling cycle.

7.1.9 Coordinate system setting function

Set the firmware coordinate system and display the corresponding firmware design coordinate system in the upper computer

Figure 9 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 twenty-four orientations for the X/Y/Z triaxial axis, as shown in the table below:

Table 24 coordinates are oriented towards the corresponding table

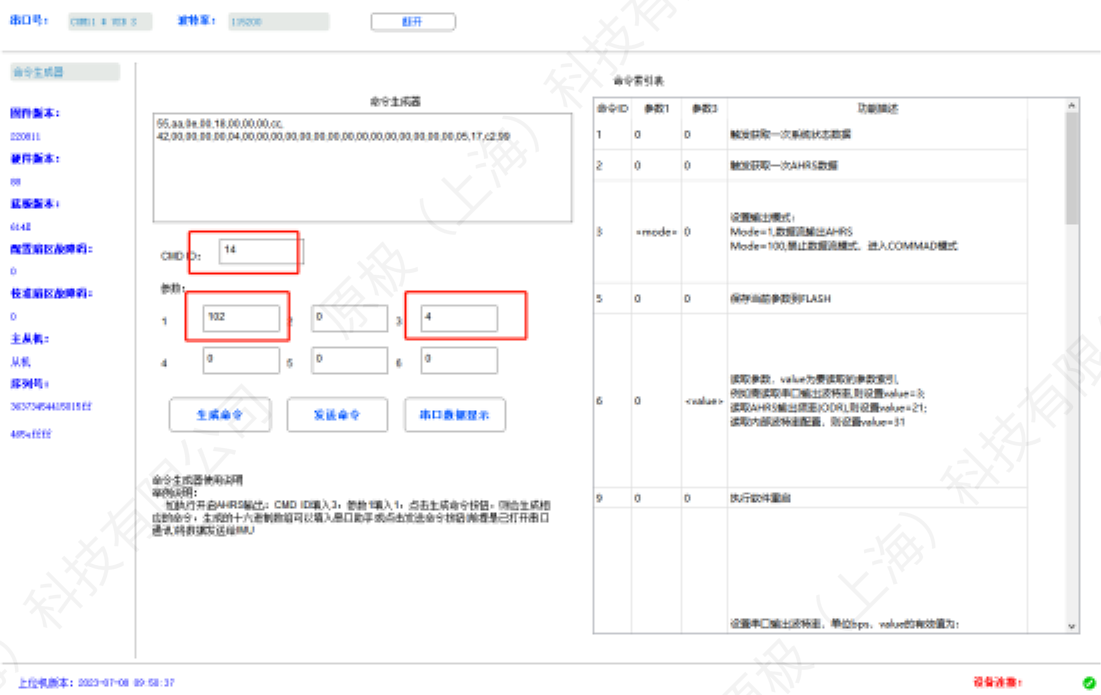
Orientation (value)	XAxis	YAXis	ZAxis	Instructions
101	+Ux	+Uy	+Uz	Default orientation
102	-Ux	-Uy	+Uz	
103	-Uy	+Ux	+Uz	
104	+Uy	-Ux	+Uz	
105	-Ux	+Uy	-Uz	
106	+Ux	-Uy	-Uz	
107	+Uy	+Ux	-Uz	
108	-Uy	-Ux	-Uz	
109	-Uz	+Uy	+Ux	
110	+Uz	-Uy	+Ux	
111	+Uy	+Uz	+Ux	
112	-Uy	-Uz	+Ux	
113	+Uz	+Uy	-Ux	
114	-Uz	-Uy	-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:

Enter 14 in CMD ID, 102 in Parameter 1, and 4 in Parameter 3. The generated hexadecimal array can be filled into the COM assistant or program array and sent to the IMU.

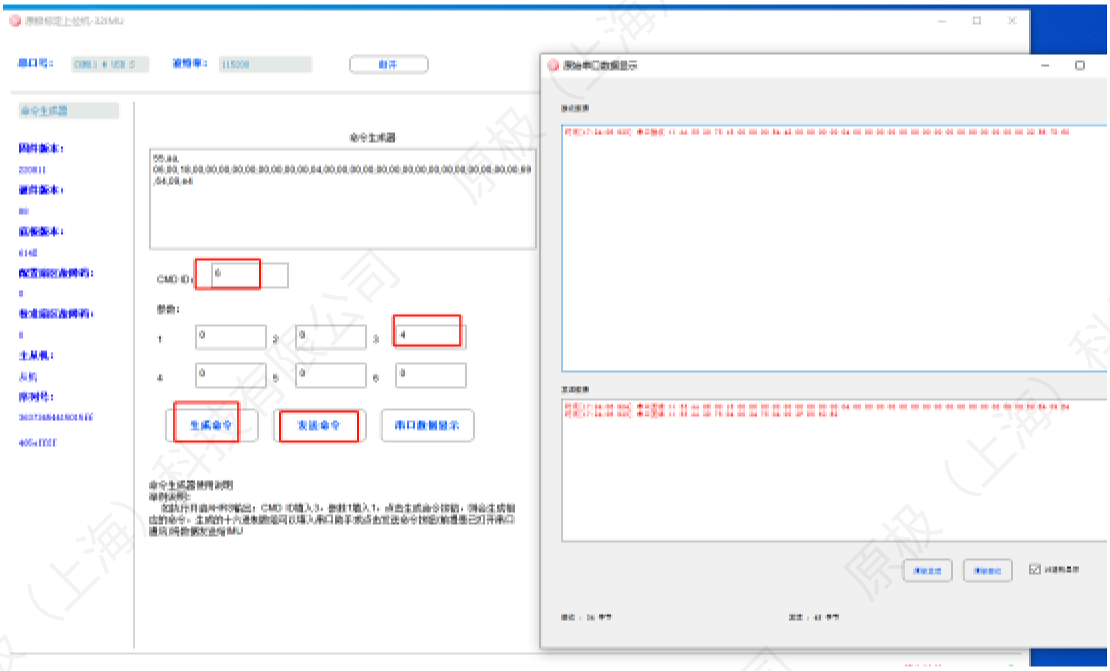
Figure 10 Change the coordinate system to 102 orientation



How to read the coordinate system orientation:

Enter 06 in CMD ID and 4 in Parameter 3. The generated hexadecimal array can be filled into the COM assistant or program array and sent to the IMU.

Figure 11 Read the coordinate system orientation



Example: Set the coordinate system to 115 orientation

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

According to Table 20, the index of Parameter is 04, and the parameter is set successfully

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 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 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 B2 2F 2D 4E

According to Table 14 and Table 15, the parsing results in 115 for parameter 1 (float) and 04 for parameter 3. That is, the coordinate system is 115 orientation

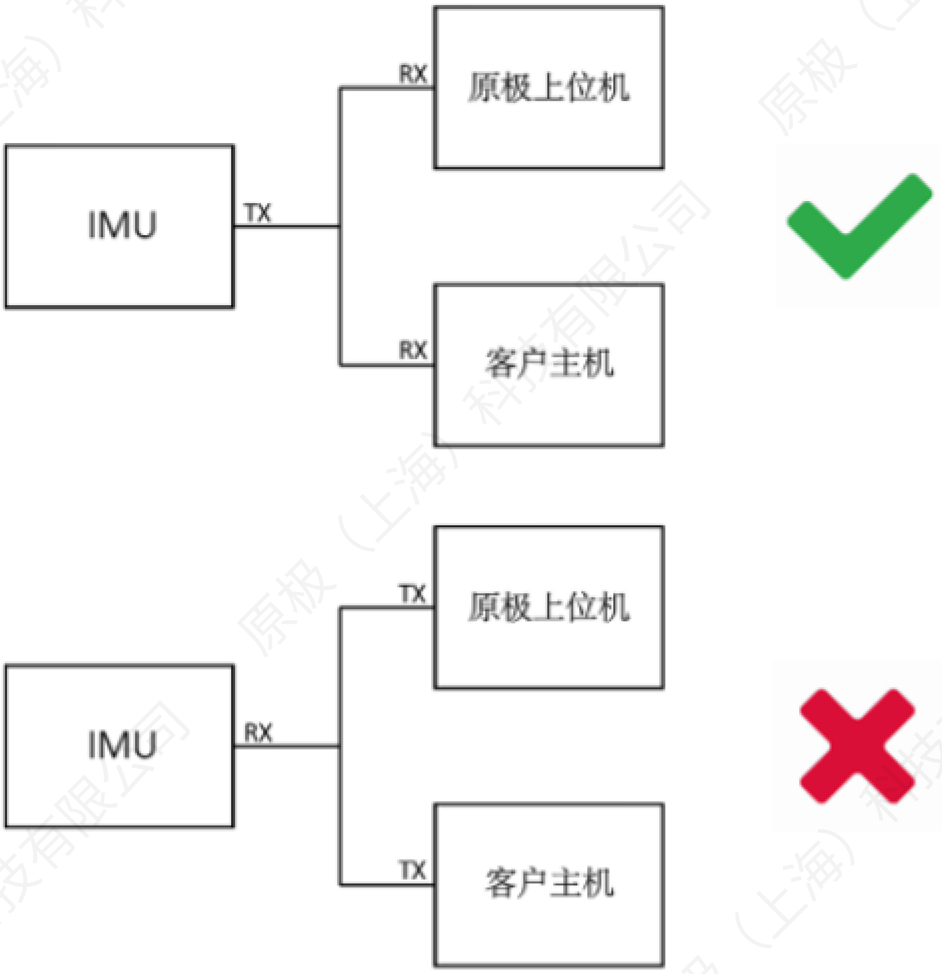
7.1.10 Serial Port Connection FAQs

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

The RX of the serial port cannot be connected to two TX at the same time, so if you need to connect the primary PC, you need to disconnect its communication with the serial port of the user host, otherwise the PC can only receive data and cannot send commands to the IMU.

As shown in the following picture:

Figure 12 Schematic diagram of serial port 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

Check whether the serial cable has lost packets. The serial cable of the FT232 chip is recommended. The CH340 and PL2303 data cables will lose packets when the baud rate is high (>115200bps)

It is recommended to connect the serial cable directly, do not recommend series, such as the interface of RS422 to connect the computer, directly use RS422 to RS232+RS232Z to USB cable series.

3) Upper computer curve display caton

If it is FT232 data line, use the system administrator to open the upper computer, and automatically configure the serial port delay

Configure the serial port delay manually in the device manager.

7.2 I2C Communication Protocol

Example of I2C host read driver based on STM32:

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

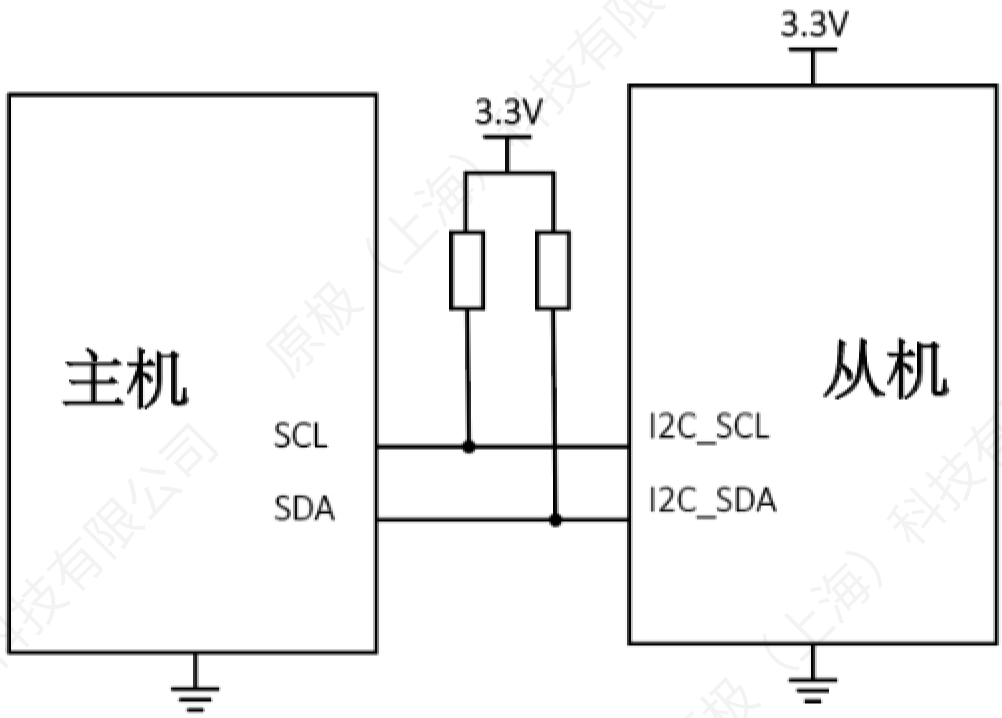
7.2.1 I2C interface Parameters

Table 25 I2C interface parameters

I2C rate	400KHz
I2C Slave address (7 bits)	0x18

7.2.2 I2C Connection Mode

Figure 13 I2C connection method



Note: The pull-up resistor has a resistance value of 4.7KΩ

7.2.3 I2C Register

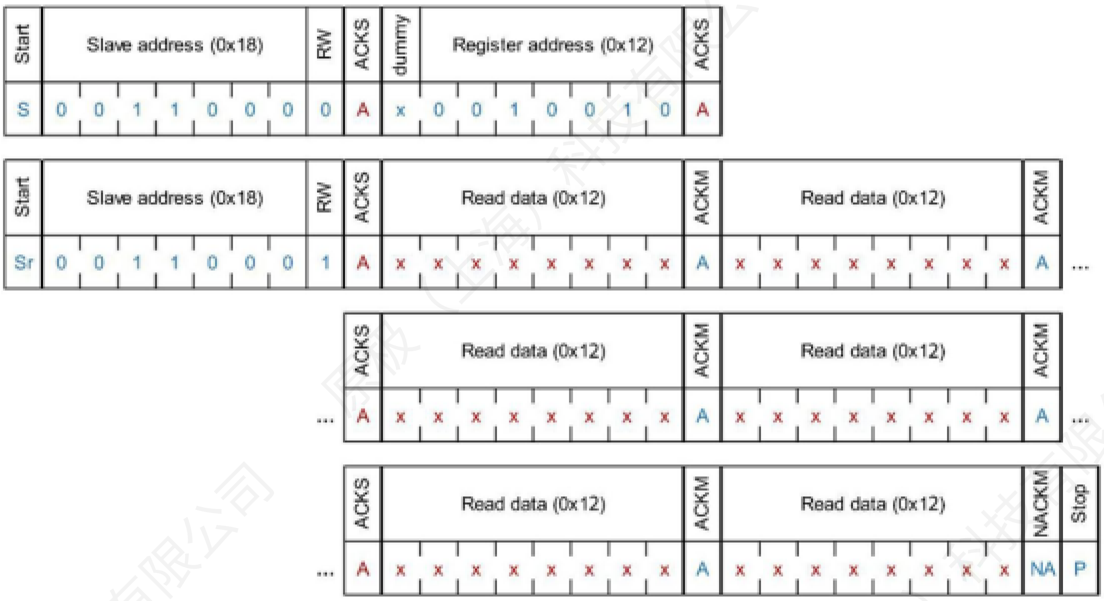
Table 26 List of I2C Register

Names	Address	Read/Write	Default	Description
BURST	0x12	R		Continuous read register
FILTER_CTRL	0x06	RW	0xBB	Filter selection
PROD_ID	0x6A	R		Product name

7.2.3.1 I2C BURST Register

This I2C protocol supports continuous reading, continuous reading register address 0x12, the slave machine automatically accumulates the address, continuous output 48 bytes in 8bit mode, the reading process is as follows:

FIG. 14 I2C continuous read mode



Frames are defined as follows:

Table 27 I2C continuous read data format

Sending sequence	1	2	3
Data format	uint32_t	float	float
Send content	TIME	ACCL_X	ACCL_Y
Send order	4	5	6
Data format	float	float	float

Send content	ACCL_Z	GYRO_X	GYRO_Y
Send order	7	8	9
Data format	float	float	float
Send content	GYRO_Z	TEMP	ROLL
Sending order	10	11	12
Data format	float	float	uint32
Send content	PITCH	YAW	CRC32

Note 1: TEMP is measured in ° C, gyroscope output is measured in °/s, accelerometer output is measured in g, and attitude output is measured in degrees

Note 2: The initial value of crc32 is 1, CRC calculation does not include all the data of this frame, refer to Appendix 1 for table calculation

7.2.3.2 I2C FILTER_CTRL register

The FILTER_CTRL register address is 0x06. The filter configuration mapping table is the same as the SPI accelerometer and gyroscope filter configuration. The register reading process is the same as the I2C BURST reading method, and the register writing process is shown in the figure below.

Figure 15 I2C FILTER_CTRL register writing method

7.2.3.3 I2C ID register

The ID register is 0x6A, and its data content is IMU61B in the ASCII format. The ID register can be read from I2C BURST, as shown in the following table.

Table 28 I2C ID register read mode

Sending sequence	1	2	3	4
What to send	0x00	0x00	0x49	0x4D
Send order	5	6	7	8
What to send	0x55	0x36	0x31	0x*

Note 1: All data is 8-bit width

Note 2:0x * indicates the contents of the product ID,0x32 for IMU612,0x34 for IMU614,0x38 for IMU618,0x41 for IMU6132A, and 0x42 for IMU6132B

7.3 SPI Communication Protocol

Example of SPI Master read driver based on STM32:

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

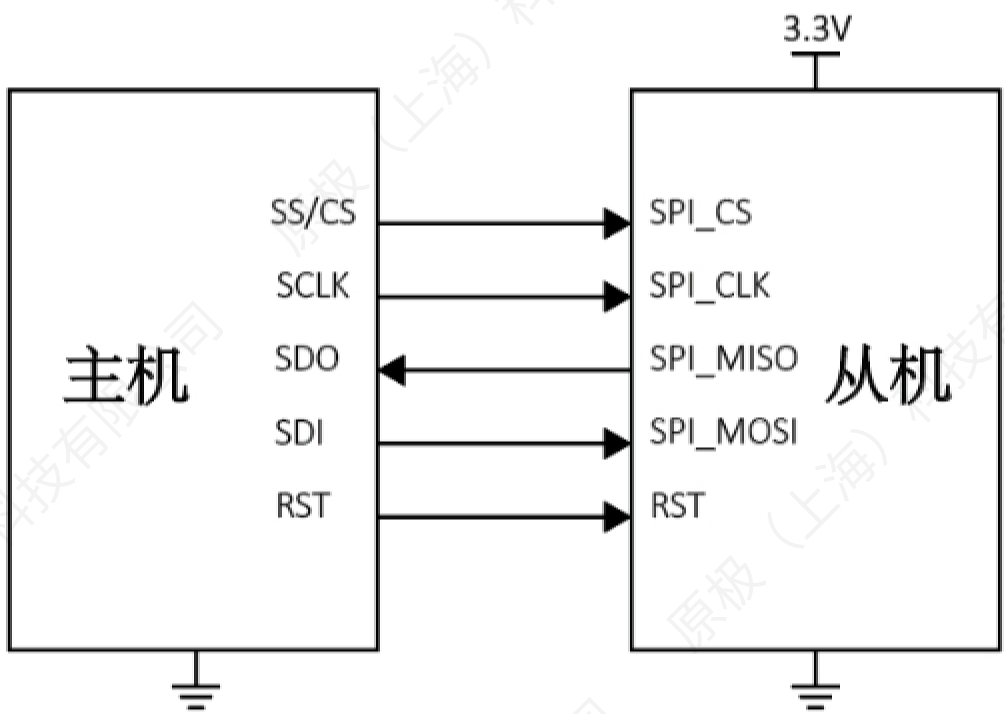
7.3.1 Parameter of the SPI interface

Table 29 SPI interface parameters

SPI host	This product acts as slave
SPI rate	0.2 to 2 MHZ
SPI word length	16bit
Phase	Rising edge trigger (Mode 3, CPHA=1)
Polarity	Idle for high (mode 3, CPOL=1)
Bit order	MSB priority

7.3.2 SPI connection diagram

Figure 16 SPI connection diagram



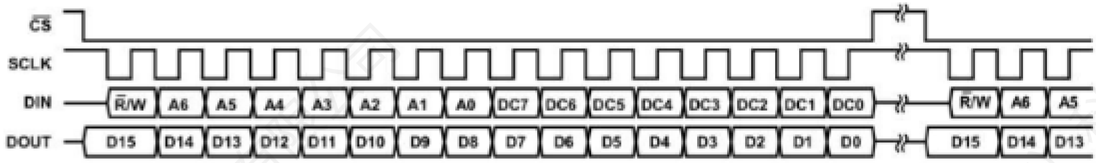
Note 1: Before the initial reading, it is necessary to reset the IMU and wait for 3s to make the IMU enter the normal working state.

Note 2: Refer to the corresponding manual for SPI pins of different IMU models

7.3.3 SPI communication bit order

The SPI interface supports full-duplex serial communication (performing both send and receive at the same time) using the bit order shown in the image below.

Figure 17 Schematic diagram of SPI communication bit order



Where, the highest DIN bit represents the read/write operation, [A6:A0] represents the register address, and [DC7:DC0] represents the data written (write operation) or DUMMY data (read operation).

When /W =1, the DOUT data of this SPI cycle is meaningless. DOUT data for this SPI cycle when /W =0

Represents the register output data of the last two cycles, see BURST read example for details.

7.3.4 SPI register

Table 30 List of SPI registers

Names	Address	Read/Write	Default	Window ID	Description
BURST	0x00	RW		0	Continuous reads
FILTER_CTRL	0 x07, 0 x06	RW	0x00BB	1	Filter selection
PROD_ID1	0x6C	R	0x494d	1	ID Number 1
PROD_ID2	0x6E	R	0x5536	1	ID Number 2
PROD_ID3	0x70	R	0x3132	1	ID number 3 (IMU612)
			0x3134	1	ID number 3 (IMU614)
			0x3138	1	ID number 3 (IMU618)
			0x3141	1	ID number 3 (IMU6132A)
			0x3142	1	ID number 3 (IMU6132B)
WIN_CTRL	0x7F,0x7E	RW	0x0000	0,1	Window ID selection

TEMP_HIGH	0x0E	R	\	0	Temperature high byte
TEMP_LOW	0x10	R	\	0	Temperature low byte
XGYRO_HIGH	0x12	R	\	0	Gyro X axis height bytes
XGYRO_LOW	0x14	R	\	0	Gyro X axis low byte
YGYRO_HIGH	0x16	R	\	0	Gyro Y-axis height bytes
YGYRO_LOW	0x18	R	\	0	Gyro Y axis low byte
ZGYRO_HIGH	0x1A	R	\	0	Gyro Z-axis height bytes
ZGYRO_LOW	0x1C	R	\	0	Gyro Z axis low byte
XACCEL_HIGH	0x1E	R	\	0	Add table X axis height bytes
XACCEL_LOW	0x20	R	\	0	Add table X axis low byte
YACCEL_HIGH	0x22	R	\	0	Add the Y-axis height bytes
YACCEL_LOW	0x24	R	\	0	Add table Y-axis low byte
ZACCEL_HIGH	0x26	R	\	0	Add table Z-axis height bytes
ZACCEL_LOW	0x28	R	\	0	Add table Z axis low byte

7.3.4.1 SPI BURST Register

BURST reads Register continuously, reading all data in a single data stream without stopping between 16-bit segments.

Table 32 SPI BURST Register format

address	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8	Read/Write
0x01									RW
Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Read/Write
0x00	BURST_CMD								RW

The BURST reading method is as follows: sending 0x8000 before reading indicates setting BURST and starting reading, and then sending 0x0000 all the time and receiving data. The output Register content is offset by 2 SPI cycles compared with the sending of the read instruction, and the chip selection level continues to be low during reading.

Figure 19 Schematic diagram of continuous reading of SPI BURST

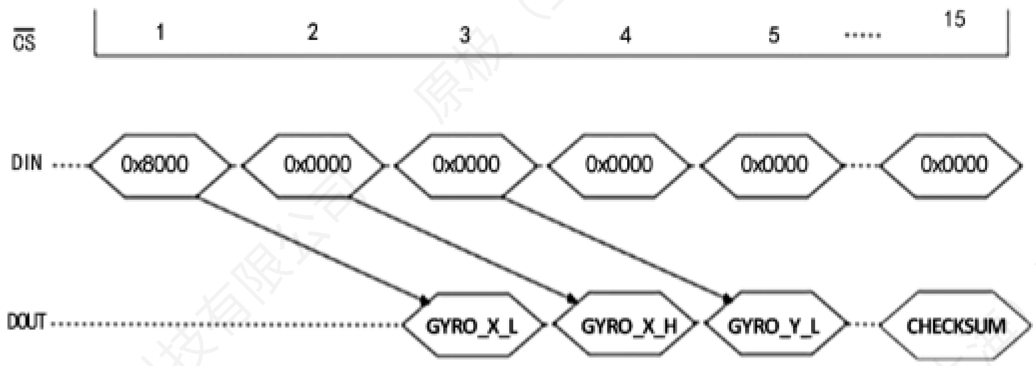


Table 33 Basic format of continuous reading by SPI BURST

Sending sequence	1	2	3	4	5	6
What to send	GYRO_X_L	GYRO_X_H	GYRO_Y_L	GYRO_Y_H	GYRO_Z_L	GYRO_Z_H
Send order	7	8	9	10	11	12
What to send	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H	ACCL_Z_L	ACCL_Z_H
Send order	13					
What to send	CHKSM					

SPI BURST2 Read the basic format continuously

To output a mode 2 data frame, write 0x02 to the Register 0x8D

Send order	1	2	3	4	5	6
What to send	GYRO_X_L	GYRO_X_H	GYRO_Y_L	GYRO_Y_H	GYRO_Z_L	GYRO_Z_H
Send order	7	8	9	10	11	12
What to send	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H	ACCL_Z_L	ACCL_Z_H
Send order	13	14	15	16	17	18
What to	TEMP_L	TEMP_H	PITCH_L	PITCH_H	ROLL_L	ROLL_H

send						
Send order	19	20	21	22	23	24
What to send	YAW_L	YAW_H	Reserved	Reserved	CHECK_L	CHECK_H

SPI BURST3 Read the basic format continuously

To output a mode 3 data frame, write 0x03 to register 0x8D

Send order	1	2	3	4	5	6
What to send	TIME	STATUS	GYRO_X_L	GYRO_X_H	GYRO_Y_L	GYRO_Y_H
Send order	7	8	9	10	11	12
What to send	GYRO_Z_L	GYRO_Z_H	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H
Send order	13	14	15	16	17	18
What to send	ACCL_Z_L	ACCL_Z_H	PITCH_L	PITCH_H	ROLL_L	ROLL_H
Send order	19	20	21	22	23	24
What to send	YAW_L	YAW_H	TEMP_L	TEMP_H	Q0_L	Q0_H
Send order	25	26	27	28	29	30
What to send	Q1_L	Q1_H	Q2_L	Q2_H	Q3_L	Q3_H
Send order	31	32				
What to send	CHECK_L	CHECK_H				

Instructions for BURST3:

TIME Indicates the counting time after the PPS arrives. The value is cleared every whole second.

STATUS Description:

Bit0: Accelerometer sensor ready flag, 0= not ready, 1= ready

Bit1: Gyroscope sensor ready flag, 0= not ready, 1= ready

Bit2: IMU calibration status: 0= not performed, 1= calibration performed

Bit3: IMU calibration successful: 0= unsuccessful, 1= successful calibration

Bit4-Bit6: Gyroscope GX, GY, GZ will set 1 in the corresponding position if it

exceeds the range, otherwise it will restore 0

Bit7: Reserved bit

Bit8: Geomagnetic sensor ready flag, 0= not ready, 1= ready, note This bit is invalid for not with geomagnetic

Bit9-Bit15: Reserved bit

Note 1: All data in BURST,BURST2,BURST3 are 16-bit widths

Note 2: Top, Accelerometer, attitude and quaternion data in BURST,BURST2 and BURST3 are expressed as int32 after concatenation

Note 3: CHKSM stands for CHECKSUM, which is used to confirm data integrity. It is calculated by summing all the data before the CHECKSUM

In the BURST continuous reading process, 32-bit complete data is divided into high 16 bits and low 16 bits respectively output, output using the small-endian mode, that is, low bytes output first. Users need to concatenate the two parts of 16-bit data to restore the complete 32-bit data.

FIG. 20 Schematic diagram of SPI32-bit data

restoration

After obtaining the complete 32-bit data, the standard frame user can convert it into angular velocity, acceleration, temperature and attitude Angle information according to the following formula.

Table 34 Standard frame SPI 32-bit data conversion formula

name	Units	Formula	Conditions/Notes
Angular Speed	° /s	G=SF/65536*GYRO	GYRO is the GYRO data for the X/Y/Z axis in the table above Gyro scale factor SF= 0.016
Acceleration	mg	A=SF/65536*ACCL	ACCL is the ACCL data for the X/Y/Z axis in the table above SF = 0.2 for Burst mode In single Register mode, SF=0.2/1000

Temperature	℃	T=SF/65536*TEMP-172621824+25	TEMP is the TEMP data in the table above Temperature scale factor SF=-1/263.4
Attitude Angle	°	D=SF/65536*ATT	ATT is the ATT data in the table above Attitude scale factor SF = 0.00699411

7.3.4.2 SPI FILTER_CTRL Register

The FILTER_CTRL Register provides the user with control over the digital low-pass filter. The Register is a read/write Register, the write command is send 0x86XX, and the current SPI cycle setting is valid. The read command is sent 0x0600, and the output Register content is offset by 2 SPI cycles than the read command is sent.

Table 34 SPI FILTER_CTRL Register format

Address	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8	Read/Write
0x07									RW
Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Read/Write
0x06	Accelerometer filter configuration				Gyro filter configuration				RW

Table 35 Filter configuration

	Encoding	Description
Accelerometer/gyroscope filter configuration	4’ b 0000	IIR filter fc=1 Hz
	4’ b 0001	IIR filter fc=1 Hz
	4’ b 0010	IIR filter fc=2 Hz
	4’ b 0011	IIR filter fc=5 Hz
	4’ b 0100	IIR filter fc=10 Hz
	4’ b 0101	IIR filter fc=15 Hz
	4’ b 0110	IIR filter fc=20 Hz
	4’ b 0111	IIR filter fc=25 Hz
	4’ b 1000	IIR filter fc=30 Hz
	4’ b 1001	IIR filter fc=35 Hz
	4’ b 1010	IIR filter fc=40 Hz
	4’ b 1011	no filter

Note: For example, if the gyro and Accelerometer filter are configured at 10Hz, the value 0x8644 is written.

7.3.4.3 SPI ID Register

The ID Register is a read-only Register, and the data content is the ASCII encoded character "IMU". The reading method is similar to that of BURST data reading: 0x6C00~0x7000 is sent when the burst data is read, and the data is received. The output Register content is offset by 2 cycles from the read instruction sending.

The complete ID of the product can be obtained by concatenating 4 16-bit ID data into ASICII code. The splicing method is the same as the splicing of data read continuously by BURST, with PROD_ID1 in the high position and PROD_ID4 in the low position.

Table 36 Format of SPI ID Register

Address	bit15 ~ bit0	Encoding	Read/Write
0x6C	PROD_ID1	0x494D	R
0X6E	PROD_ID2	0x5536	R
0x70	PROD_ID3 The encoded content represents the product ID	0x3132(IMU612)	R
		0x3134(IMU614)	R
		0x3138(IMU618)	R
		0x3141(IMU6132A)	R
		0x3142(IMU6132B)	R

7.3.4.4 SPI WIN_CTRL register

This register is used to control the switch window ID and can be read and written. The window default is 0, write 0xFE01, then switch to 1.

Table 37 Format of SPI WIN_CTRL register

Address	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8	Read/Write
0x7F									RW
Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Read/Write
0x7E	WINDOW_ID								RW

Table 38 SPI register WIN_CTRL.WINDOW_ID encoding

Name	Code	Description
WINDOW_ID	0x00	window0, start reading data
	0x01	window1, go to Configuration

7.4 Common AT instructions

7.4.1 Stop the current data stream output

Instruction: AT+SETNO\r\n

Answer: OK

You can stop the current data stream (without changing the Parameter of the data stream), and the output is OK, indicating that the next operation can be carried out.

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

Turn on data stream output

Instruction :AT+SETYES\r\n

7.4.2 Query version number

Instruction: AT+VERSION\r\n

Answer: SW_VERSION Firmware version
HW_VERSION Hardware version
BOARD_VERSION Backboard version
OK

7.4.3 Querying User Parameter

Instruction: AT+CONFIG\r\n

Answer: BAUD_RATE Baud rate of the current serial port
ORIENT current coordinate system
IMU_ODR Output frequency of the current IMU
STREAM_MODE1 Stream mode of serial port 1
STREAM_MODE2 Stream mode of serial port 2
STREAM_MODE3 Stream mode of serial port 3
LP_CONFIG_REG Filtering of the current IMU
OK

7.4.4 Setting and Querying the ODR

Example: Set output frequency ODR to 50hz

Instruction: AT+SET_ODR=50\r\n

Answer: IMU_ODR:50
OK

query the ODR instruction of IMU
: AT+GET_ODR\r\n

Reply: IMU_ODR:
OK

7.4.5 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:
OK
Query the IMU current coordinate system
Instruction: AT+GET_ORIENT\r\n
Answer: orientation:101
OK

7.4.6 Setting and Querying the Baud rate

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=
OK

7.4.7 Set the roll and pitch inversion

AT+SET_ATT_ORIENTATION=00\r\n Roll pitch does not invert
AT+SET_ATT_ORIENTATION=01\r\n roll reverse, not reverse pitch
AT+SET_ATT_ORIENTATION=10\r\n roll is not reversed, pitch is reversed
AT+SET_ATT_ORIENTATION=11\r\n roll and pitch are inverted

7.4.8 Set and query filters

Example: Set the filter of the IMU to 20hz
Instruction: AT+SET_LPF=102\r\n
Answer: LP_CONFIG_REG:102
OK
Query the IMU current filter
Instruction: AT+GET_LPF\r\n
Answer: LP_CONFIG_REG:
OK

Table 39 Low-pass filter values and AT instruction corresponding values

Serial Number	IMU low-pass filter value	The value corresponding to the AT instruction
1	1	17
2	2	34
3	5	51
4	10	68
4	15	85
5	20	102
6	25	119
7	30	136
8	35	153
9	40	170
10	47(no filtering)	187

7.4.9 Set the initial heading Angle

Example: Set the initial heading Angle to 180 degrees (integers only supported)

Instruction: AT+SET_HEADING=180\r\n

Answer: AT+SET_HEADING=180

7.4.10 Save parameters

Instruction: AT+SAVE\r\n

Answer: OK

7.5 CAN Communication protocol

Example of CAN host read driver based on STM32:
https://data.forsense-imu.com/page/download.html

7.5.1 Communication Parameter

Interface form: CAN, standard frame
CAN rate: 250Kbps~1Mbps (configurable)

7.5.2 Standard frame format

Table 40 CAN Standard Frame Format 101

Standard Frame ID	1	2	3	4	5	6	7	8
0x65+ node	ROLL				PITCH			

Table 41 CAN Standard Frame Format 102

Standard Frame ID	1	2	3	4	5	6	7	8
0x66+ node	YAW				Gx			

Table 42 CAN Standard Frame Format 103

Standard frame ID	1	2	3	4	5	6	7	8
0x67+ Node	Gy				Gz			

Table 44 CAN Standard Frame Format 104

Standard Frame ID	1	2	3	4	5	6	7	8
0x68+ node	Ax				Ay			

Table 45 CAN Standard Frame Format 105

Standard Frame ID	1	2	3	4	5	6	7	8
0x69+ node	Az				TEMP		INDEX	

Note 1: Attitude Angle, gyro, Accelerometer data is expressed as float, temperature, meter value data is expressed as int16
Note 2: The unit of TEMP is 100* ° C, the unit of gyroscope output is °/s, the unit of accelerometer output is g, and the unit of attitude output is degree

7.5.3 CAN parameter configuration

7.5.3.1 Configuring the CAN Baud Rate

Configure the CAN baud rate and send instructions:

ID=0x619, DATA=0x20 0x21 0x22 0x23 0xXX 0x00 0x00 0x00

The IMU replies as follows:

ID=0x519, DATA=0xXX 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

To query the CAN baud rate, send instructions:

ID=0x619, DATA=0x20 0x21 0x22 0x23 0x0A 0x00 0x00 0x00 0x00

The IMU replies as follows:

ID=0x519, DATA= 0xXX 0x0A 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

Where:

XX=01 baud rate is 250Kbps

XX=02 baud rate is 500Kbps

XX=03 baud rate is 1000Kbps

7.5.3.2 Configuring the Node ID

The default node is 100, set the node ID to 0X0102, and send the command:

ID=0x61A, DATA=0x30 0x31 0x32 0x33 0x01 0x02 0x00 0x00

The IMU replies as follows:

ID=0x51A, DATA=0x01 0x02 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

7.5.3.3 Querying the version Number

Send instructions:

ID=0x618, DATA=0x10 0x11 0x12 0x13 0x00 0x00 0x00 0x00 0x00

The IMU replies as follows:

ID=0x518, DATA=0x00 0x03 0x12 0x0E 0xFF 0xFF 0xFF 0xFF 0xff

The version number is :0X0003120E, that is, firmware version number: 201230

7.5.3.4 Check/Set the terminal resistor

Remove the terminal resistor and send the command:

ID=0x61B, DATA=0x10 0x11 0x12 0x13 0x01 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x51B, DATA=0x01 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Add terminal resistor, send instruction:

ID=0x61B, DATA=0x10 0x11 0x12 0x13 0x02 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x51B, DATA=0x02 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

7.5.3.5 Setting the Output frequency

Set the output frequency and send instructions:

ID=0x61C, DATA=0x10 0x11 0x12 0x13 0xXX 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x51C, DATA=0xXX 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

Query the output frequency and send instructions:

ID=0x61C, DATA=0x10 0x11 0x12 0x13 0x0A 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x51C, DATA=0xXX 0x0A 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

Where:

XX=01 The output frequency is 1HZ

XX=02 The output frequency is 10HZ

XX=03 The output frequency is 50HZ

XX=04 The output frequency is 100HZ

XX=05 The output frequency is 200HZ

7.5.3.6 Check/Set roll pitch inversion

Set roll pitch take reverse, send command:

ID=0X61D,DATA=0X10 0X11 0X12 0X13 XXXX 0XFF 0XFF 0XFF

The IMU replies as follows:

ID=0X51D,DATA=XXXX 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF

Query roll pitch take inverse state, send instruction:

ID=0X61D,DATA=0X10 0X11 0X12 0X13 0X0A 0XFF 0XFF 0XFF

The IMU replies as follows:

ID=0X51D,DATA=XXXX 0X0A 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF

Where:

XXXX=0X00 Roll Angle and pitch Angle are not reversed

XXXX=0X01 roll Angle and pitch Angle are not inverted

XXXX=0X10 Roll angle is inverted, and Pitch angle is inverted

XXXX=0X11 Roll angle is inverted, and Pitch angle is inverted

7.5.3.7 Check/set the filter cutoff frequency

Set the filter cutoff frequency and send instructions:

ID=0X61E,DATA=0X20 0X21 0X22 0X23 XXXX 0XFF 0XFF 0XFF

The IMU replies as follows:

ID=0X51E,DATA=XXXX 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF

Query the filter cutoff frequency status and send instructions:

ID=0X61E,DATA=0X20 0X21 0X22 0X0A 0XFF 0XFF 0XFF 0XFF

The IMU replies as follows:

ID=0X51E,DATA=XXXX 0X0A 0XFF 0XFF 0XFF 0XFF 0XFF 0XFF

Where:

XXXX=0X44 Cut-off frequency 10HZ

XXXX=0X66 Cut-off frequency 20HZ

XXXX=0XAA Cut-off frequency 40HZ

XXXX=0XBB Cutoff frequency 47HZ

7.5.3.8 Querying or Setting the Coordinate System

Set the coordinate system and send instructions:

ID=61F,DATA=0X30 0X31 0X32 0X33 XXXX 0XFF 0XFF 0XFF

The IMU replies as follows:

ID=0x51F,DATA= XXXX 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Query the orientation Settings, send instructions:

ID=0x61F, DATA=0x30 0x31 0x32 0x0A 0xFF 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x51F, DATA=XXXX 0x0A 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

Where:

XXXX=0X65 Default orientation

CAN is configured in hexadecimal and displayed in decimal in section 8. Refer to Section 8 of the manual for specific orientation Settings

7.5.3.9 Turning off/Subtracting Attitude Angle

Set off/deduct attitude Angle or deduct attitude Angle to send command:

ID=0x620, DATA=0x10 0x11 0x12 0x13 XXXX 0xFF 0xFF 0xFF

The IMU replies as follows:

ID=0x520, DATA=XXXX 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

To check whether the attitude Angle setting is deducted, send the command:

ID=0x620, DATA=0x10 0x11 0x12 0x0A 0xFF 0xFF 0xFF 0xff

The IMU replies as follows:

ID=0x520, DATA=XXXX 0x0A 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff

Where:

XXXX=0X01 minus attitude Angle

XXXX=0X00 No attitude Angle is deducted

7.5.3.10 Save instruction

Send instructions:

ID=0x6FF, DATA=0x10 0x11 0x12 0x13 0xFF 0xFF 0xFF 0xF

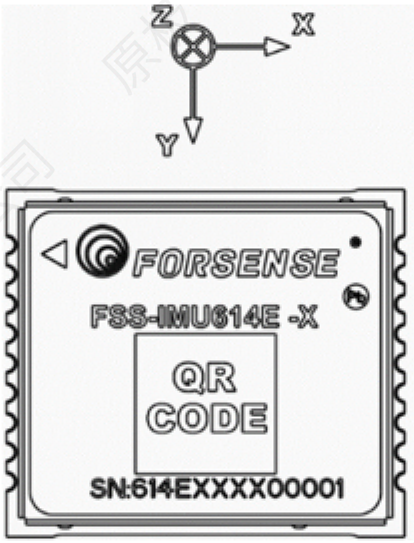
The IMU responds as follows:

ID=0x5FF, DATA=0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xff 0xff

The storage takes time. The packets are returned only after the storage is successful. After the storage is successful, the restart takes effect

8. Define the coordinate system

Figure 20 Definition of coordinate system



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

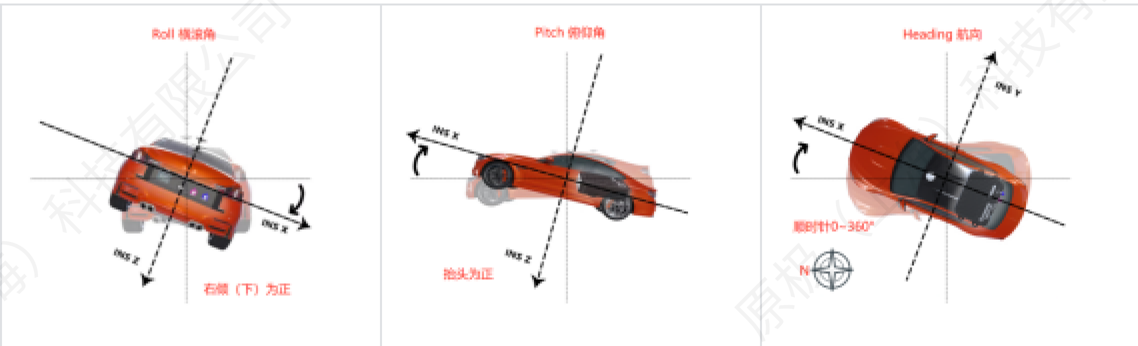
Rotation around the Z axis: Course Angle Yaw range: 0° ~360°

Rotation around the X-axis direction: Roll Angle Roll range: -180°~180°

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

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

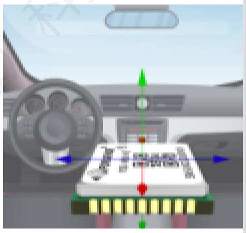
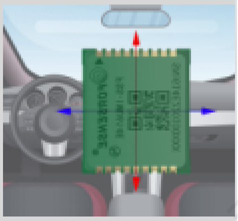
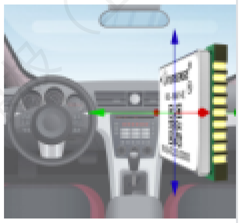
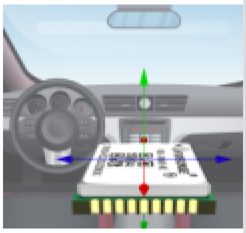
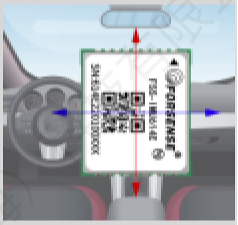
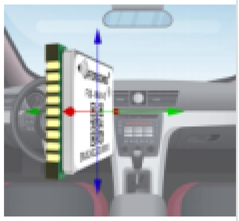
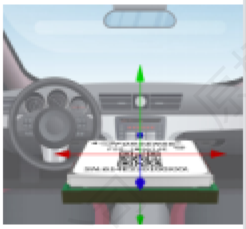
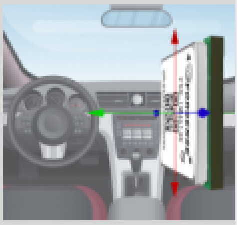
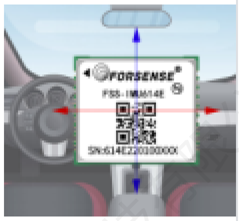
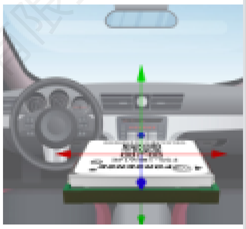
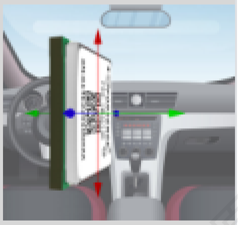
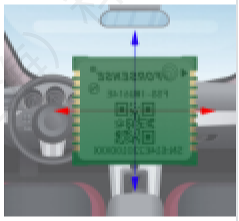
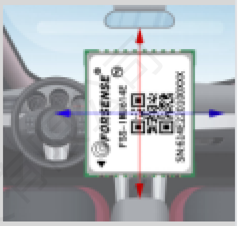
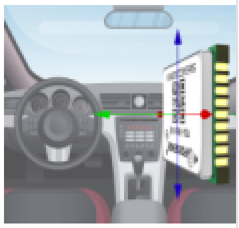
FIG. 21 Schematic diagram of roll, pitch and heading Angle

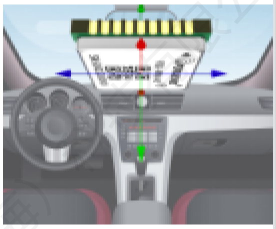
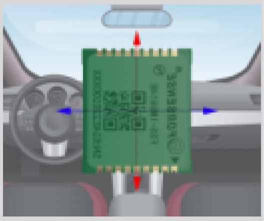
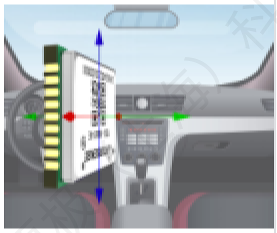
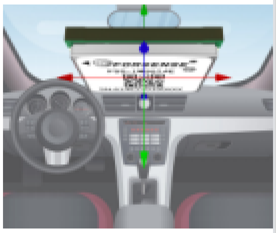
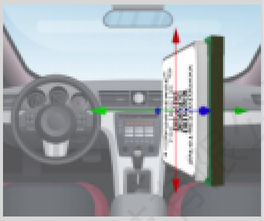
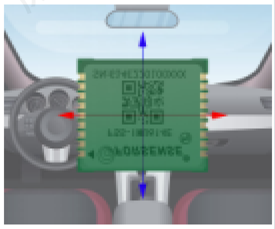
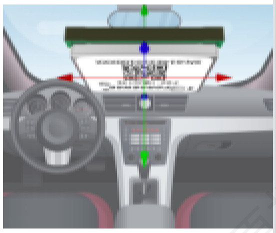
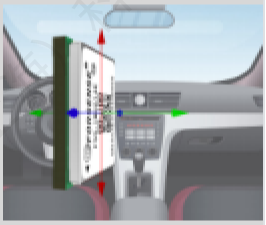
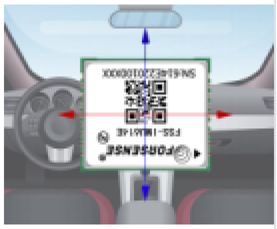


Schematic diagram of mounting coordinate system

Schematic illustration: For ease of understanding, take the relative position of the IMU module in the internal space of the passenger car as an example.

The direction of the front is the front, the Angle of the lens is the back, and the relative position can be confirmed by the direction of the arrow on the module label Adjusting the installation coordinate system is to adjust the definition of XYZ three axes, so that XYZ three axes always meet the requirements of X facing forward, Y facing right and Z facing down

Coordinate System	Schematic diagram	Coordinate system	Schematic diagram	Coordinate system	Schematic diagram
101		109		117	
102		110		118	
103		111		119	
104		112		120	
105		113		121	

Coordinate system	Schematic diagram	Coordinate system	Schematic diagram	Coordinate system	Schematic diagram
106		114		122	
107		115		123	
108		116		124	

9.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
```

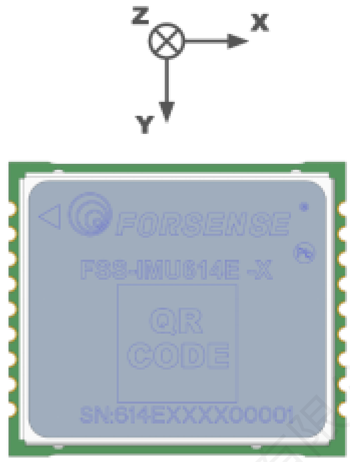
```
 ,0xf00f9344, 0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d,  0x806567cb
 ,0x196c3671,  0x6e6b06e7,  0xfed41b76,  0x89d32be0,  0x10da7a5a,
0x67dd4acc
 ,0xf9b9df6f,  0x8ebeeff9,  0x17b7be43,  0x60b08ed5,  0xd6d6a3e8,
0xa1d1937e
 ,0x38d8c2c4,  0x4fdff252,  0xd1bb67f1,  0xa6bc5767,  0x3fb506dd,
0x48b2364b
 ,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;
 }
```

10 Use examples

10.1 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.

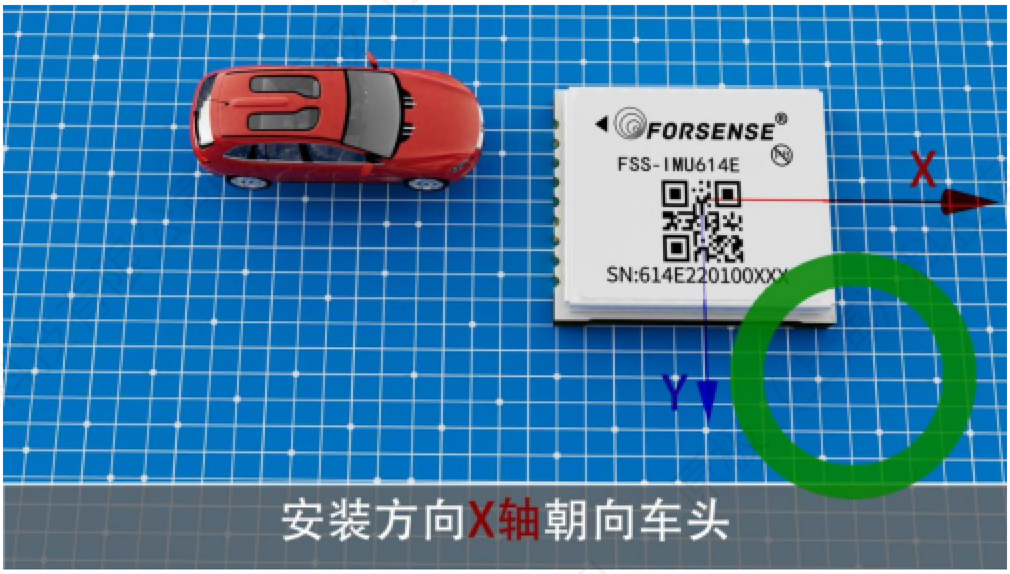
Figure 21 Schematic diagram of installing the module



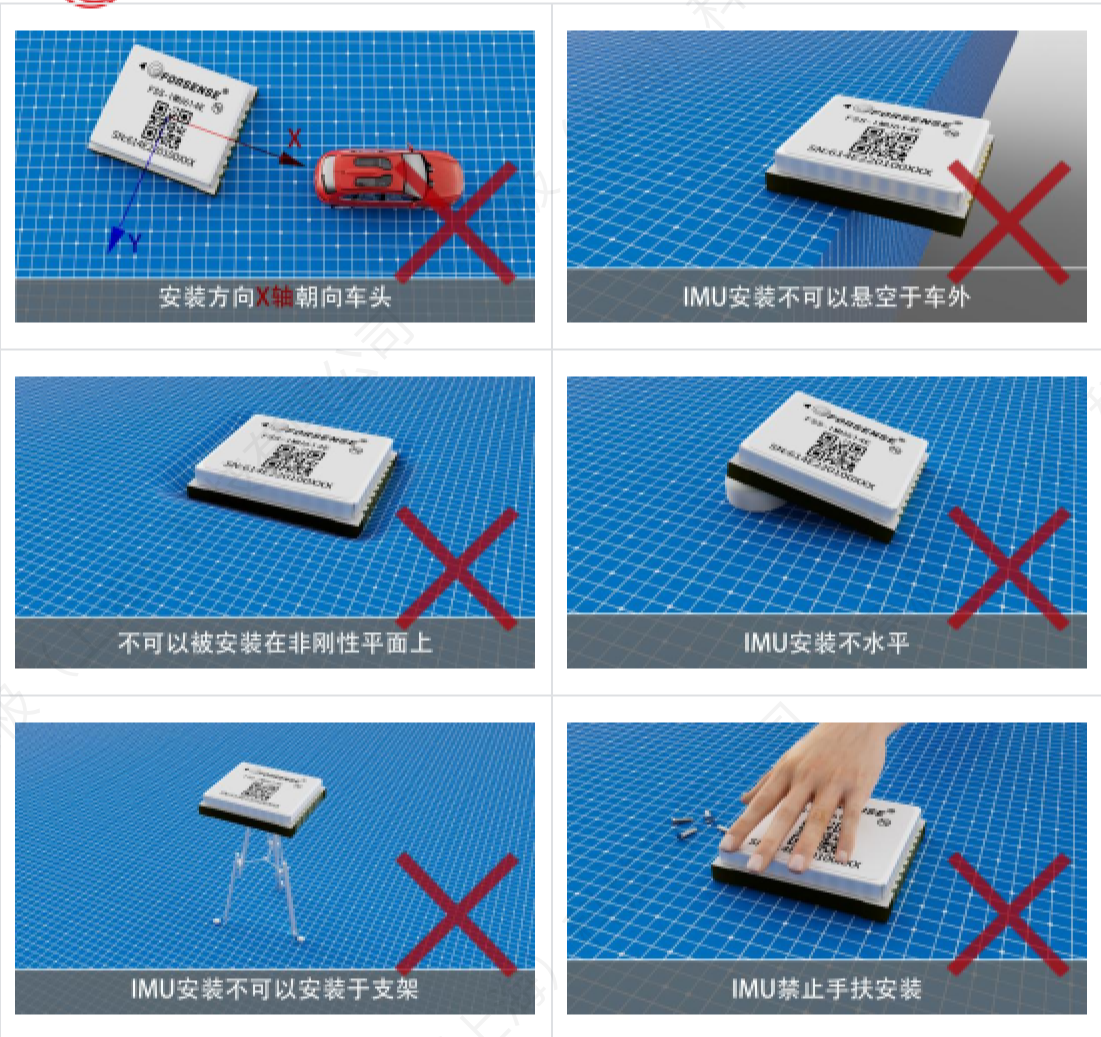
The correct installation diagram is as follows

The X axis faces the front of the car

Figure 22 Diagram of correct installation



The following installation methods are incorrect installation



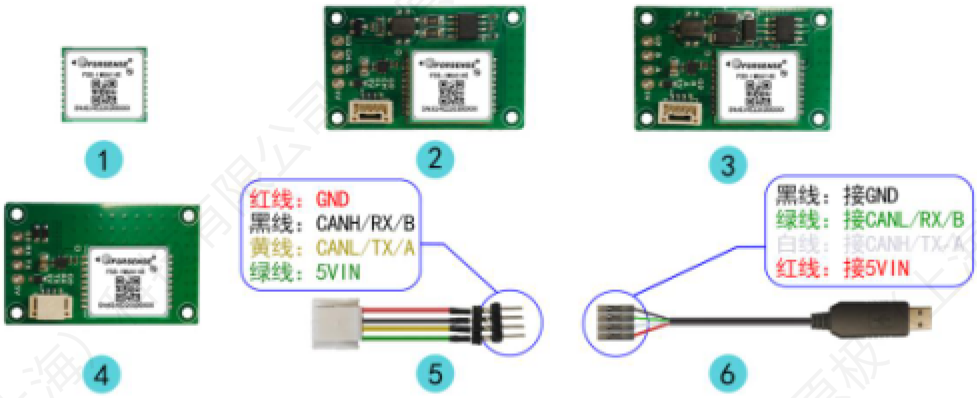
3. Precautions for IMU installation

Do not use glue or other flowing liquid around the IMU to prevent liquid from flowing into the IMU through gaps and affecting the IMU performance.

Figure 23 Schematic diagram of incorrect installation

10.2 Example for Connecting a Upper computer software

FIG. 24 Schematic diagram of module connecting to Upper computer software



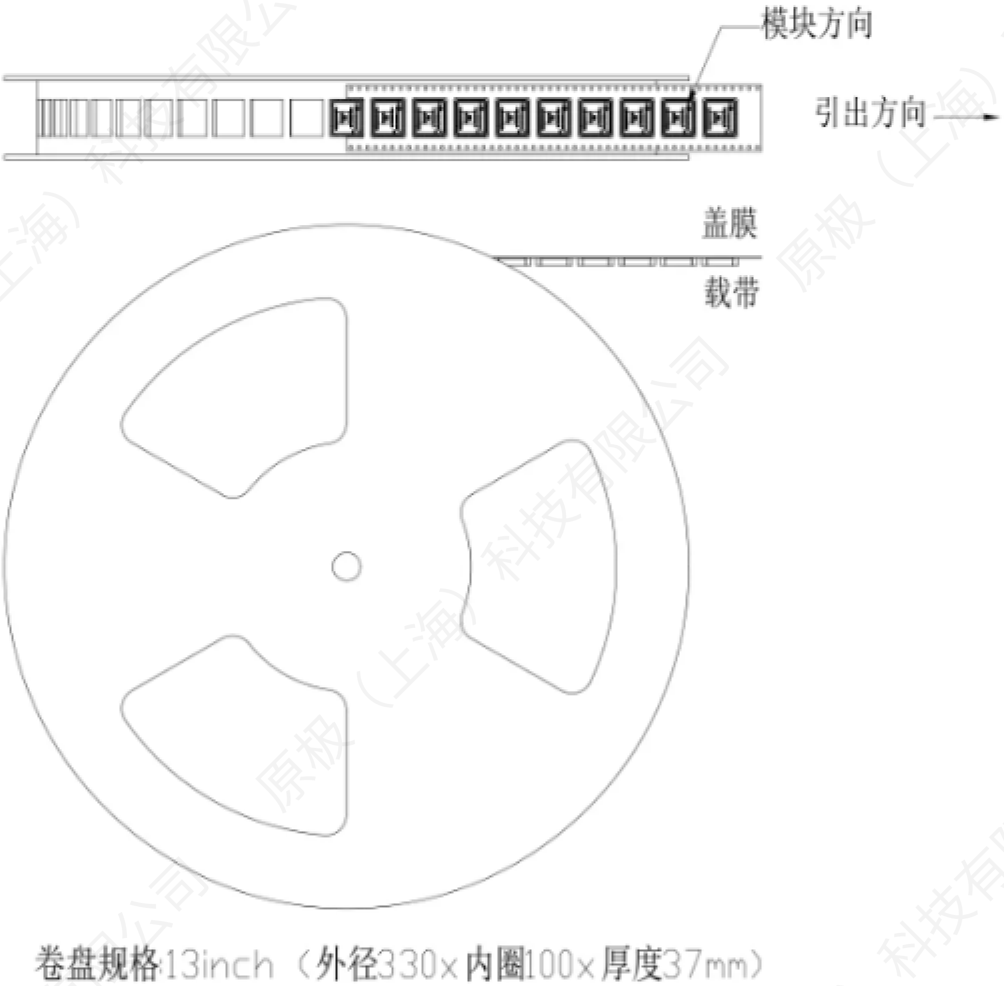
	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	贴片CAN版本测试底板	1个
3	贴片485版本测试底板	1个
4	贴片TTL版本测试底板	1个
5	4-PIN 接头	1个
6	TTL串口线	1个

11. Packaging

The IMU614E-Q module is sealed with a roll tape. For efficient production.

11.1 Roll and tape packaging

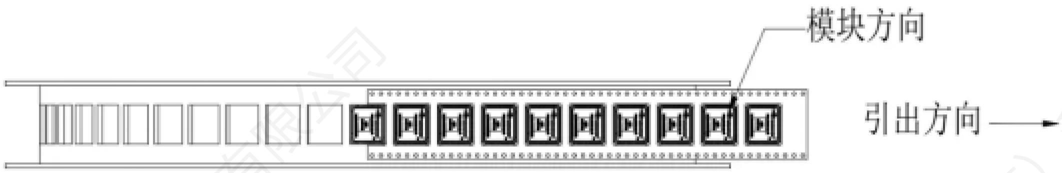
Figure 24 Schematic diagram of reel tape packaging



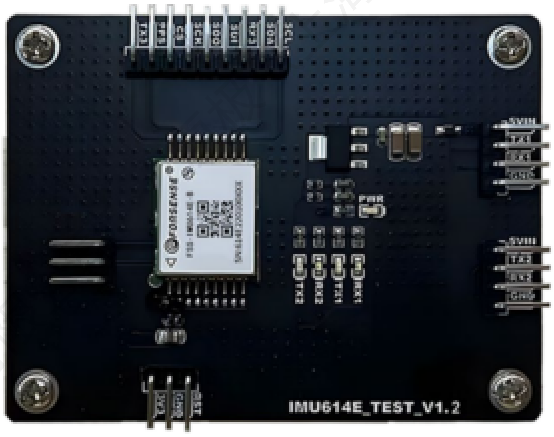
11.2 Carrier Tape

The following figure shows the position and direction of the IMU614E-Q module on the load belt before delivery:

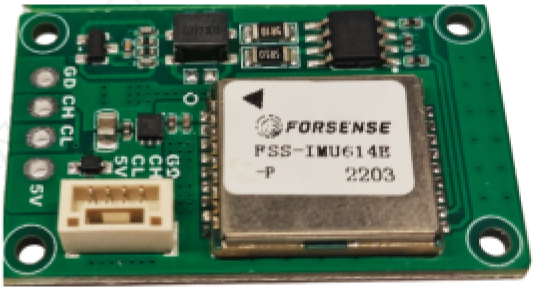
Figure 25 Position and direction of the IMU614E-Q on the load belt



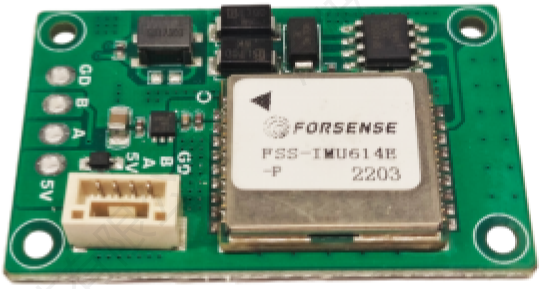
12. Select accessories



IMU614E-X Test Base Plate (new base plate)



Patch CAN version IMU614E Series



IMU614E Series Patch 485 version

Patch TTL Version IMU614E Series

TTL Serial cable

USB to CAN module

Type-C cable

13 Modify the record

Versions	date	Status/Comments
Version 1.0	2023.11.10	First Edition
Version 1.1	2023.12.01	Update Command Mode
Version 1.2	2023.12.14	Add attachments
Version 1.3	2024.02.04	Updating electrical characteristics
Version 1.4	2024.02.27	Update reflow curve and ESD protection
Version 1.5	2024.03.26	Update the Pin definition
Version 1.6	2024.05.10	Add Upper computer software connection diagram
Version 1.7	2024.10.29	Parameter update
Version 1.8	2024.11.15	Update SPI communication protocol