



**FORSENSE**  
原极科技

# Tactical MEMS 6 degrees of freedom inertial sensor

## FSS-IMU614E-T Product manual

### Features

#### Tactical grade MEMS gyroscope

- 2°/hr Bias instability
- 0.09°/√hr Angle random walk

#### Tactical grade MEMS accelerometer

- 20μg Bias instability
- 0.025m/s /√hr velocity random walk

#### Independent turntable calibration

- Independently calibrate each module:
- sensitivity, Bias instability, 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°C ~ 85°C
- 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-T 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

- Field of application: Drones

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!

## Directory:

1. Performance Parameter .....	4
1.1 Key indicators of gyroscope .....	4
1.2 Key indicators of accelerometer .....	4
2. External structure .....	7
3. Electrical characteristics .....	8
3.1 Maximum tolerance value .....	8
3.2 Working Conditions .....	8
3.3 I/O Threshold Characteristics .....	9
4. Pin definition .....	10
5. Recommend the welding furnace temperature curve .....	12
6. ESD protection .....	14
7. Communication protocols .....	15
7.1 Serial Communication Protocol .....	15
7.1.1 Parameters of serial port interface .....	15
7.1.2 Packet Format .....	15
7.1.3 Data Flow Frame -- AHRS data .....	16
7.1.4 Command Mode GET Output -- System status .....	17
7.1.5 Command mode GET output -- Read Parameter .....	17
7.1.6 Command mode SET instruction .....	18
7.1.7 Command Mode Output -- User command response .....	21
7.1.8 DRDY .....	22
7.1.9 Coordinate system setting function .....	23
7.1.10 Serial Port Connection FAQs .....	26
7.2 I2C Communication Protocol .....	27
7.2.1 I2C interface Parameters .....	27
7.2.2 I2C Connection Mode .....	27
7.2.3 I2C register .....	28
7.2.3.1 I2C BURST Register .....	28
7.2.3.2 I2C FILTER_CTRL register .....	29
7.2.3.3 I2C ID register .....	29
7.3 SPI Communication Protocol .....	30
7.3.1 SPI interface parameters .....	30
7.3.2 SPI connection diagram .....	31
7.3.3 SPI communication bit order .....	31
7.3.4 SPI register .....	32
7.3.4.1 SPI BURST Register .....	33
7.3.4.2 SPI FILTER_CTRL register .....	35
7.3.4.3 SPI ID Register .....	35
7.3.4.4 SPI WIN_CTRL register .....	36
8.1 Connecting the PPS Signal and GPRMC Packet .....	37
8.1.1 Hardware connection .....	37
8.1.2 RTK Configuration Requirements: .....	37
8.1.3 IMU enable time synchronization without sending instructions, ensure that the wiring .....	37
8.1.4 How Do I Confirm the Time synchronization success? .....	37
8.1.5 How Do I Verify that the timestamp is Correct After Time synchronization .....	39
8.2 Do time synchronization on the host using DRDY signal signals .....	41
8.2.1 DRDY Signal Function .....	41
8.2.2 How do I turn on the DRDY signal .....	42
8.2.3 DRDY Signal .....	42

9. Definition of coordinate system .....	44
10. CRC table lookup method .....	47
11 Use examples .....	49
11.1 Device Installation .....	49
11.2 Example for Connecting a Upper computer software .....	52
12. Packaging .....	53
12.1 Roll and tape packaging .....	53
12.2 Carrier Tape .....	54
13. Select accessories .....	55

## 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
Measuring range			+ 2000		°/s
Zero bias instability 1	@ 25 ° C, ALLAN variance, 1 $\sigma$		x: 3 yz: 2		°/hr
Zero bias stability	National military standard, 10s smooth		xy: 10 z: 5		°/hr
Zero bias repeatability	National Army mark		xy: 15 z: 8		°/hr
Resolution			0.0305		°/s
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		50		Hz
ODR			1000		Hz
Measuring delay			5.4		ms
Offset error over temperature	-40 ~ 85°C, <=1°C/ min@1 $\sigma$		0.03		°/s
Random Walk 1	@ 25 ° C, ALLAN variance, 1 $\sigma$		0.09		°/Vhr
Calibration coefficient error			3		‰
Calibration coefficient nonlinearity	@ 25 °C		50		ppm

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

### 1.2 Key indicators of accelerometer

Table 2 Key indicators of accelerometer

Parameters	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			Plus or minus 32		g
Bias instability instability 1	@25, ALLAN variance, 1 $\sigma$		20		Mu g



Bias instability stability	National military standard, 10s smooth	70	Mu g
Bias instability repeatability	National Army mark	xy: 0.1 z: 0.3	mg
Resolution		0.4883	mg
Non-orthogonal between axes		0.05	deg
Internal low-pass cutoff frequency	Software adjustable	50	Hz
ODR		1000	Hz
Measuring delay		5.4	ms
Full temperature range zero deviation variation	-40 ~ 85℃, <=1℃/ min@1σ	xy: 0.8 z: 2	mg
Random Walk 1	@25 ° C, ALLAN variance, 1σ	0.025	m/s/vhr
Calibration coefficient error		1	‰
Calibration coefficient nonlinearity	@ 25 °C	100	ppm

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



FIG. 1 Typical ALLAN variance curve of gyroscope

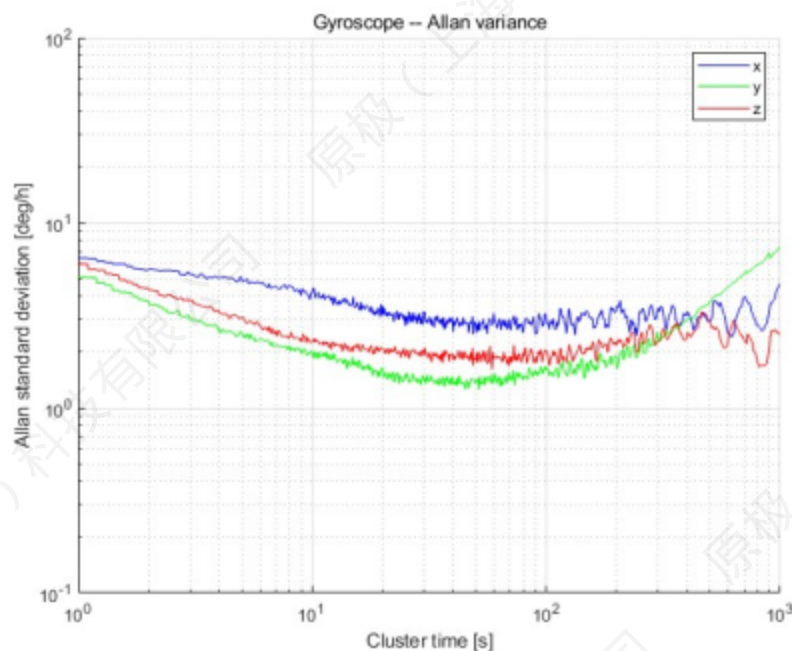
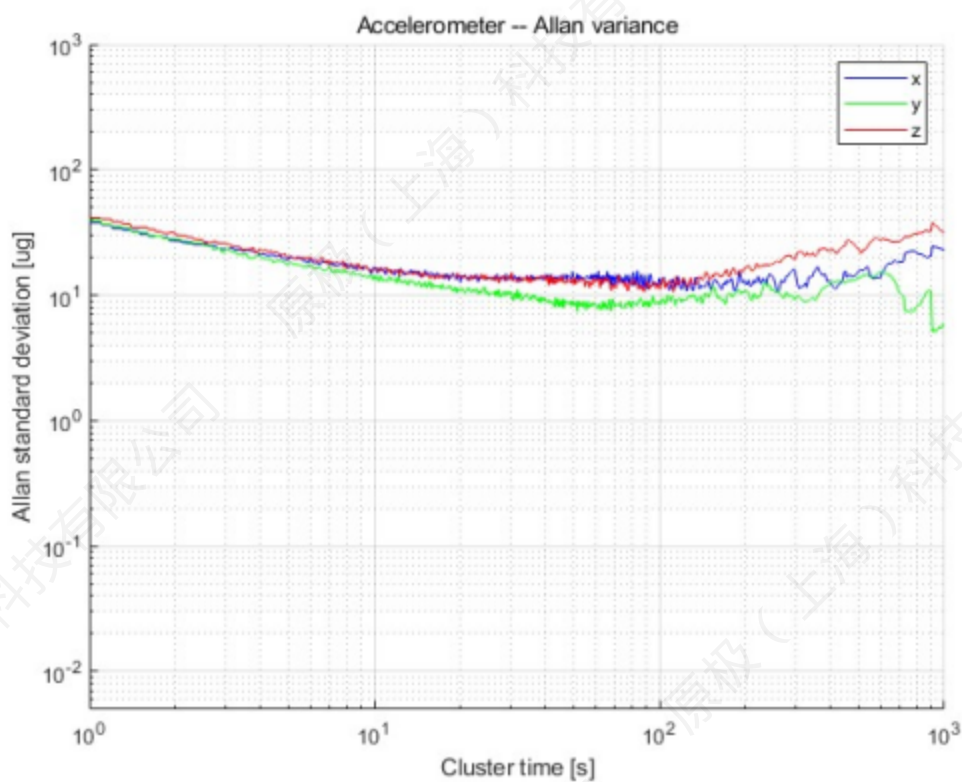
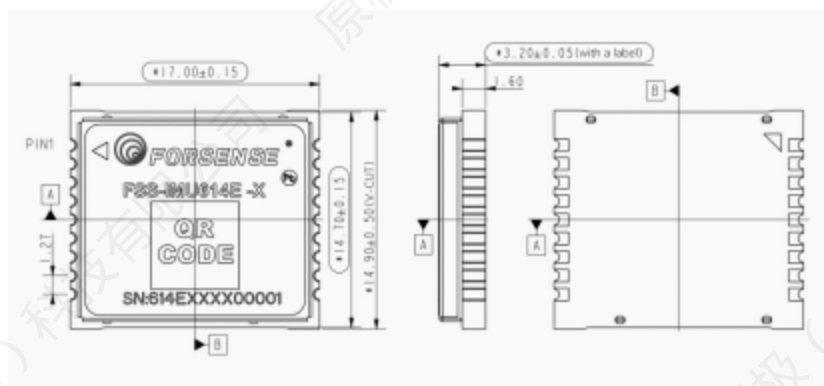


FIG. 2 Typical curve of ALLAN variance for accelerometer

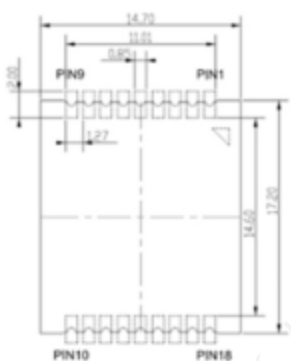


## 2. External structure

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



Dimensions of Outline structure

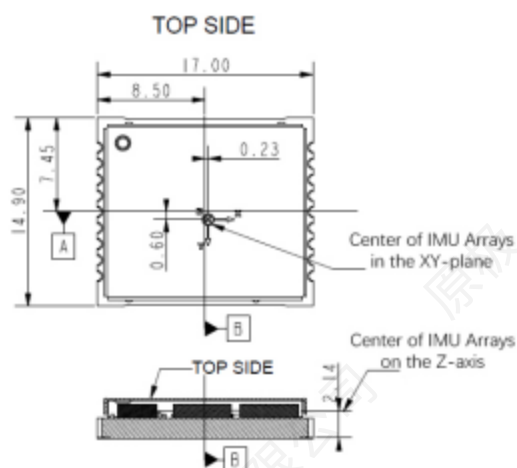


TOP VIEW  
Recommended PCB pad size chart (unit: mm)



Recommended pad size

Figure 4 Coordinate center of IMU (unit: mm)



### 3. Electrical characteristics

#### 3.1 Maximum tolerance value

Table 3 Maximum absolute rating

Parameters	Symbols	Range	Units
Supply voltage	VCC	-0.3 to 4	V
Power source	GND	-	-
Input pin voltage	Vin	-0.3 to VCC+0.2	V
Operating Temperature (Tot)	Tot	-40 to 85	°C
Storage Temperature (Tstg)	Tstg	-40 to 85	°C

#### 3.2 Working Conditions

Table 4 Working conditions

Parameter	Symbols	Minimum value	Typical value	Maximum value	Units
Supply voltage	VCC	3.2	3.3	3.4	V
VCC maximum ripple	Vrpp		+ 40		mV
Power Consumption	P		0.08		W
Operating Temperature (Tot)	T	-40		85	°C
Storage Temperature (Tstg)	T	-40		85	°C



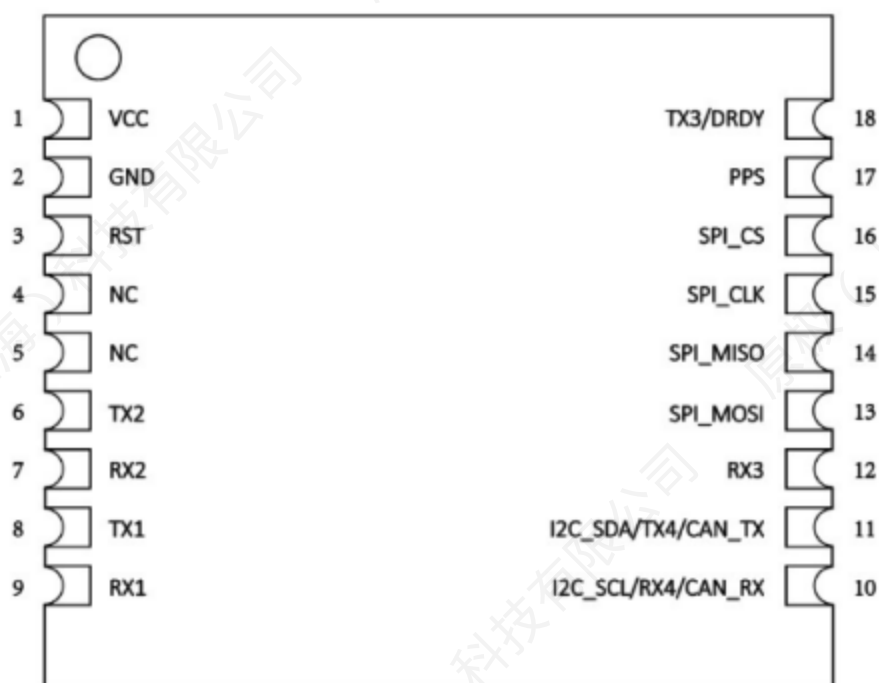
### 3.3 I/O Threshold Characteristics

Table 5 I/O Threshold Characteristics

Parameter	symbol	Minimum value	Typical value	Maximum value	Units
Input pin low	Vin_low	0		$VCC * 0.2$	V
Input pin high	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 5 Pin diagram



IMU614E-X Pin Layout (Top View)

Table 6 Pin definitions

Pin serial number	Pin name	Pin description		
1	VCC	Power input, +3.3V input, 40mA, ripple not greater than $\pm 40\text{mV}$		
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	Receives asynchronous data output		
7	RX2	Receives asynchronous data input		
8	TX1	Receive asynchronous data output (Data Communication Interface (LVTTTL))		
9	RX1	Receive asynchronous data input (Data Communication Interface (LVTTTL))		
10	CAN RX / RX4 / I2C_SCL	Mode	Features	Description
		1	CAN_RX	CAN receive Pin; And reads



				data from the bus to the CAN controller
		2	RX4	Receives asynchronous data input
		3	I2C_SCL	I2C Serial clock
11	CAN TX / TX4 / I2C_SDA	Mode	Features	Description
		1	CAN_TX	CAN send Pin; Read data from the CAN controller to the bus driver
		2	TX4	Receives asynchronous data output
		3	I2C_SDA	I2C serial data
12	RX3	Receives asynchronous data input		
13	SPI_MOSI	SPI serial data input		
14	SPI_MISO	SPI serial data output		
15	SPI_CLK	SPI Serial clock		
16	SPI_CS	SPI slice selection		
17	PPS	External synchronous sampling trigger signal; (Access RTK second pulse pin)		
18	TX3/DRDY	Receives asynchronous data output/available for Data Ready		

Note 1: The IMU hardware needs to be reset once using /RST 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 6 Welding furnace temperature curve

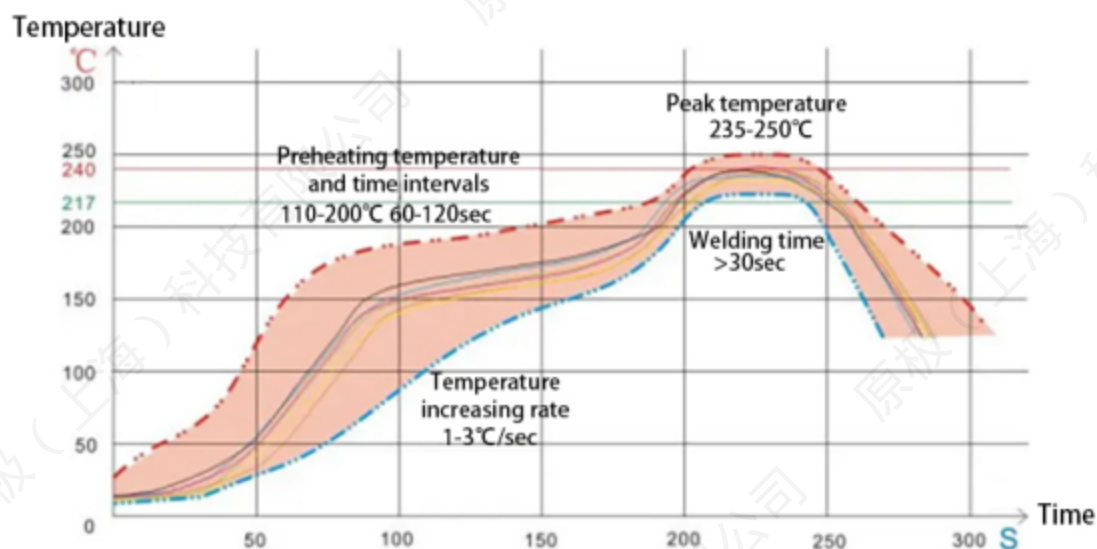


Table 7 Temperature setting mode

Items	Minimum Boundaries	Highest 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 information about modules, see the [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°C (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°C ~ 290°C, 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 electrostatic protection of the module is particularly important, and the production and transportation process needs to be strictly in accordance with the electrostatic protection, which must comply with 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>

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.

#### 7.1.1 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 COM frame ID
3		ID high byte	The upper byte of the COM frame ID
4	uint16	Data length low	The lowest byte of the frame length of the COM communication. Length is the number of bytes occupied by the payload, that is, n
5		High data length	length indicates 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 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 Serial port A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	μs	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



### 7.1.4 Command Mode GET Output -- System status

Table 12 serial port system status data format

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

Table 13 Serial 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 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[n]	Uint8	All that follows is reserved bytes

### 7.1.5 Command mode GET output -- Read Parameter

Table 14 COM Parameter Input data format

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

Table 15 COM Parameter output data format

	Frame header	Frame header	ID	length	payload	Frame trailer
Data type	uint8	uint8	uint16	uint16	P	uint32
Coding	0xAA	0x55	0x0006	0x0018		crc32

Table 16 Serial port P load data format

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 17 Index table of Parameter of COM P load

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 23 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	

### 7.1.6 Command mode SET instruction

Table 18 COM Input command formats

	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 19 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	Reserved. The default value is 0
20	Param6	Int32	Keep, default is 0

Table 20 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	Set 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 parameter, value is the index of the parameter to be read, that is, p.dex. For details, 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: 115200,460800,921600,1500000 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 23 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 computer command generator function can be used to generate corresponding commands to send, see the use of the host computer section of this manual

For example, to enable AHRS output:

CMD ID fill in 3, parameter 1 fill in 1, the generated hexadecimal array can be filled in the serial assistant or program array sent to the IMU.

Figure 7 Turn on AHRS output

#### Command Generator

55,aa,03,00,18,00,00,00,80,3f,00,00,00,00,00,00,00,00,00,00,00,00,00,00,52,d8,8e,e8

CMD ID:

3

Parameters:

1 1 2 0 3 0  
4 0 5 0 6 0

Generate

Send



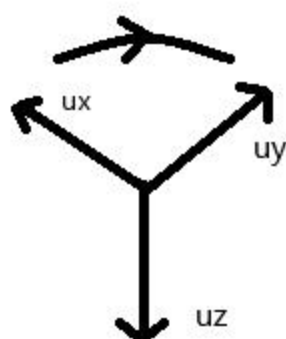


completed. After the DRDY is pulled down, the data frame will be sent from the COM, and the DRDY pin will be pulled up again in the next IMU sampling period.

### 7.1.9 Coordinate system setting function

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

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

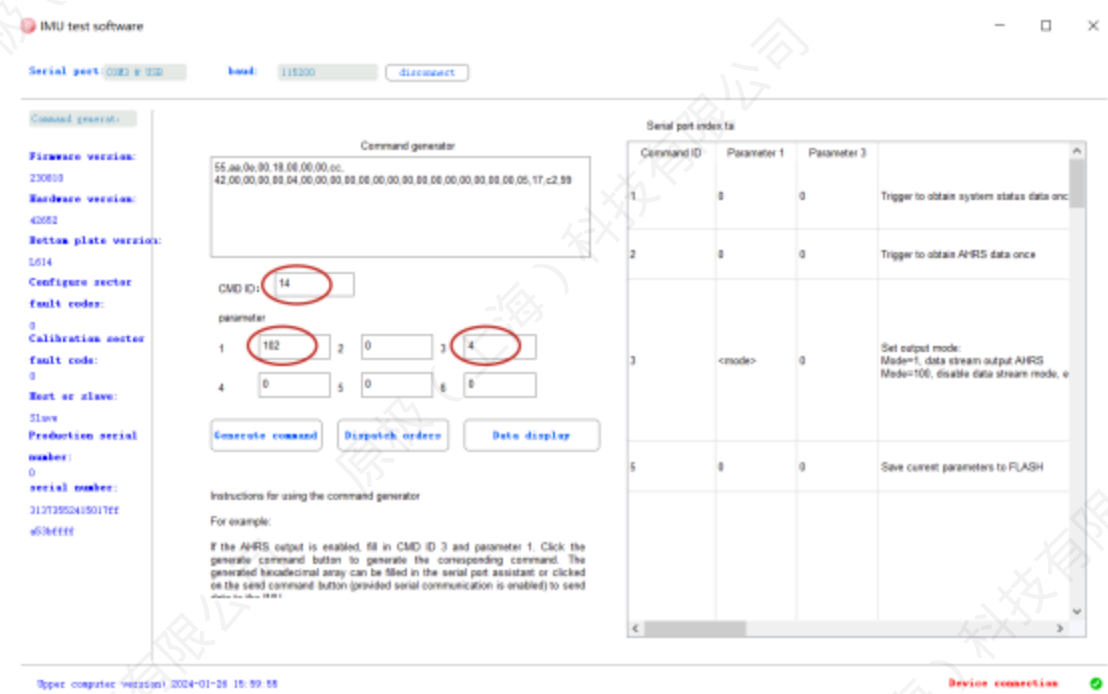
Table 24 coordinates are oriented towards the corresponding table

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.



How to read the coordinate system orientation:

Enter 06 for CMD ID and 4 for parameter 3. The generated hexadecimal array can be filled into the serial assistant or program array and sent to the IMU.





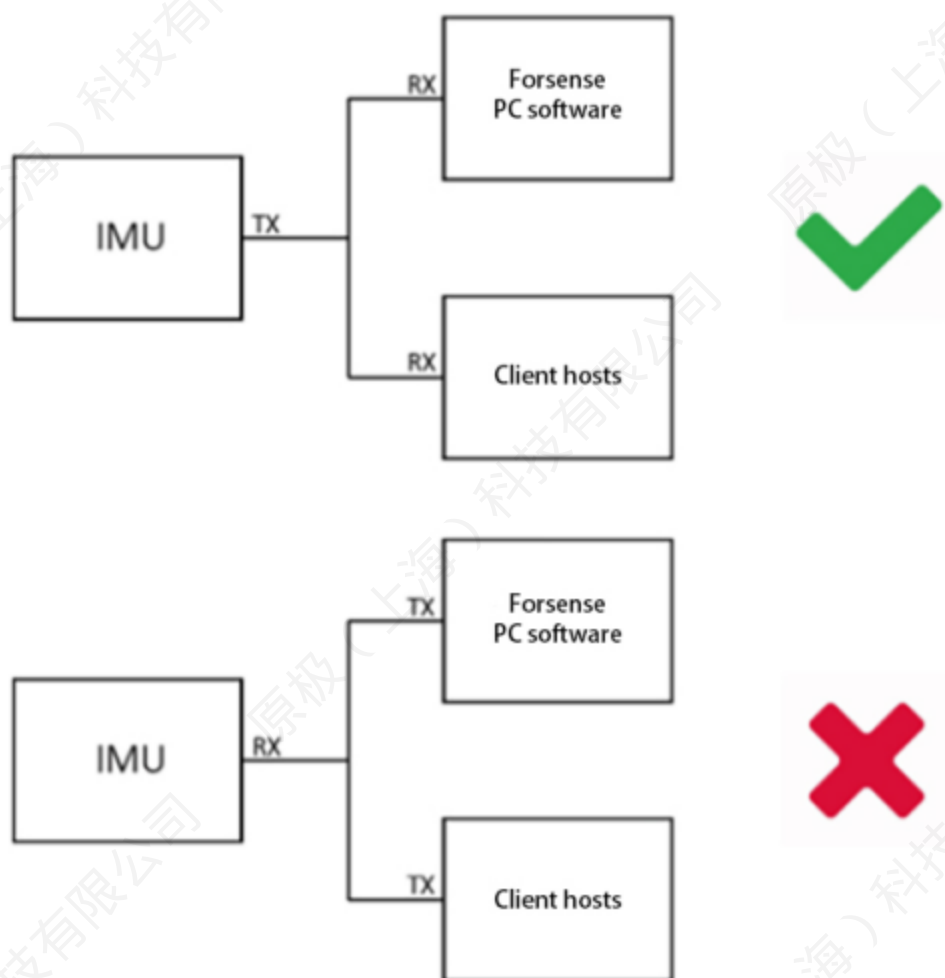
### 7.1.10 Serial Port Connection FAQs

#### 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 10 Schematic diagram of serial port connection



Note: IMU TX can be connected to multiple RXs, but RX **can not** be connected to multiple TXs;  
 IMU serial port can not be connected to both the client host and Forsense PC software at the same time;  
 IMU can reserve another serial port to connect to only Forsense PC software.

#### 2) The version number cannot be obtained

You are advised to use the serial cable of the FT232 chip. CH340 and PL2303 data cables may 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>

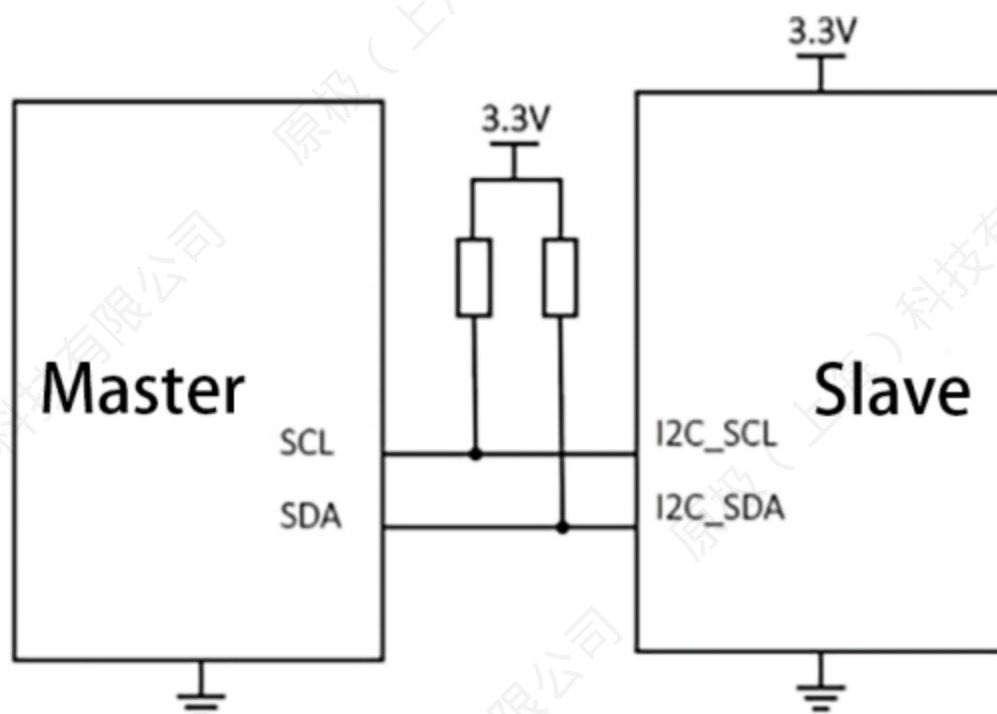
### 7.2.1 I2C interface Parameters

Table 25 I2C interface parameters

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

### 7.2.2 I2C Connection Mode

Figure 11 I2C connection method



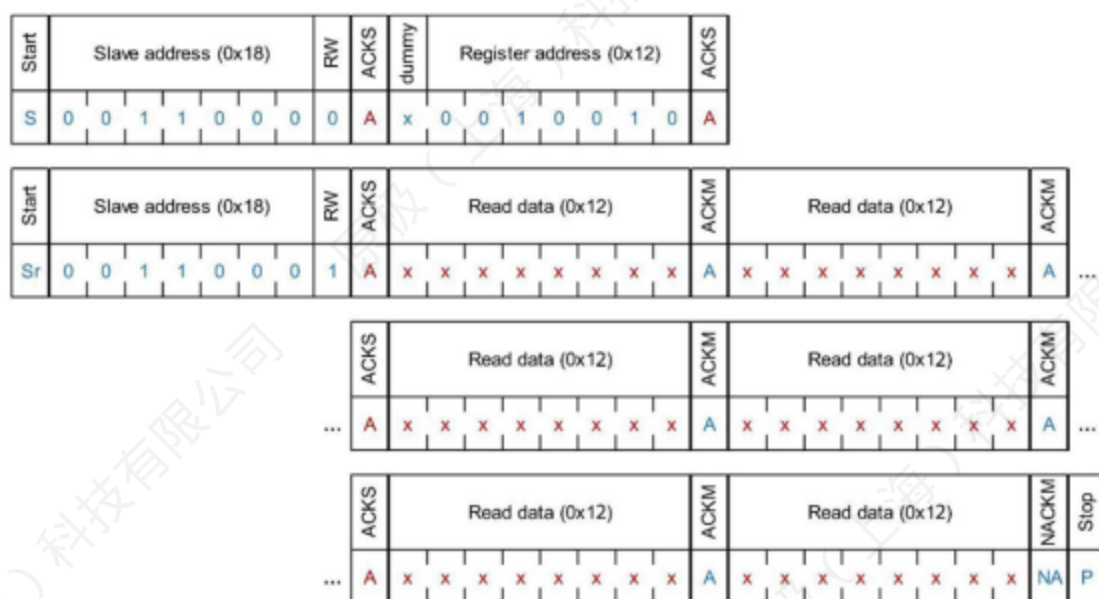
Note: The pull-up resistor has a resistance value of 4.7KΩ

### Table 26 List of I2C registers

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

This I2C protocol supports continuous reading, continuous reading register address 0x12, the slave machine automatically accumulates the address, continuous output 32 bytes in 8bit mode, the reading process is as follows:

Figure 12 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	uint32
Send content	GYRO_Z	TEMP	CRC32

Note 1: The unit of TEMP is °C, the unit of gyroscope output is °/s, the unit of accelerometer output is g, and the unit of attitude output is degree

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 13 I2C FILTER\_CTRL register writing method

Start	Slave address (0x18)	RW	ACKS	dummy	Register address (0x06)	ACKS	Data (0x01)	ACKS	Stop
S	0 0 1 1 0 0 0	0	A	0	0 0 0 0 0 1 1 0	A	0 0 0 0 0 0 0 1	A	P

### 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 host read driver based on STM32:

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

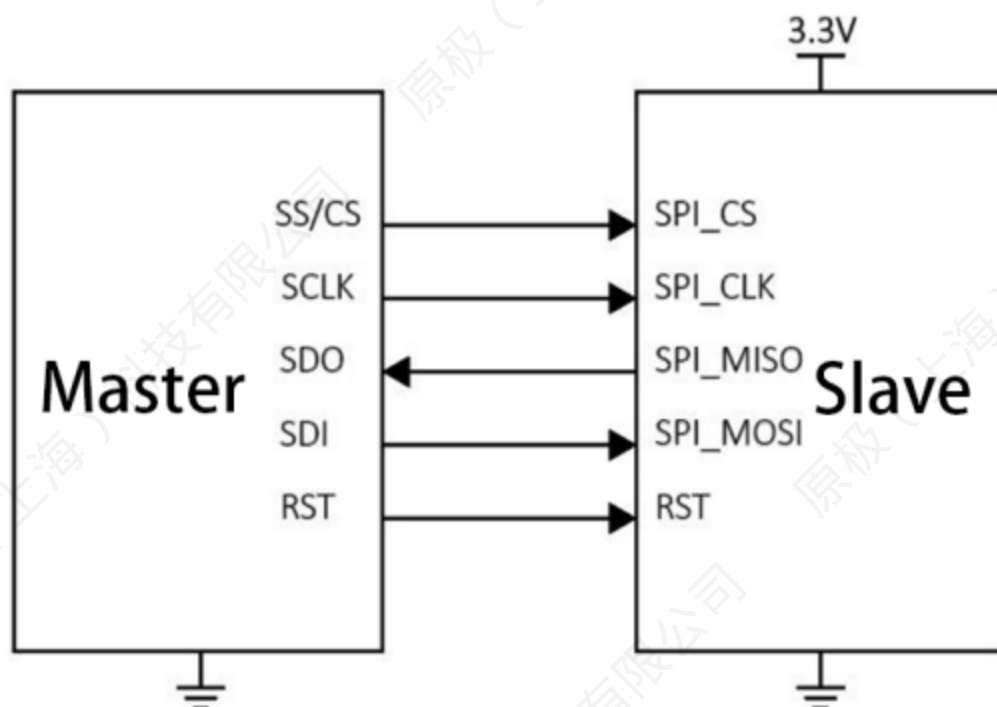
### 7.3.1 SPI interface parameters

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 14 SPI connection diagram



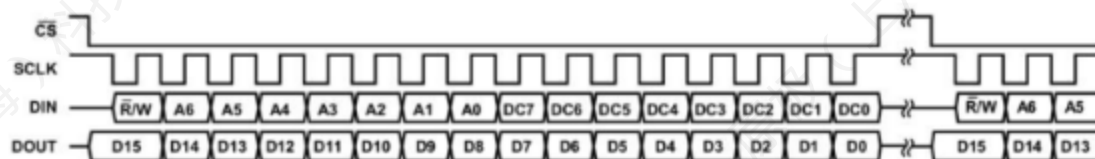
Note 1: Before the initial reading, it is necessary to reset the IMU and wait for 3s to make the IMU enter the normal working state.

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 15 Schematic diagram of SPI communication bit order



Where, the DIN highest 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

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

DOUT data for this SPI cycle when /W =0

Indicates 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	0x07, 0x06	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 bytes
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 table 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 31 Format of SPI BURST Register

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

The method of reading BURST is: sending 0x8000 before reading means setting BURST and starting reading, then sending 0x0000 and receiving data all the time, the output register content is offset by 2 SPI cycles than the sending of reading instruction, and the chip selection low level is kept during reading.

Figure 16 Schematic diagram of continuous reading of SPI BURST

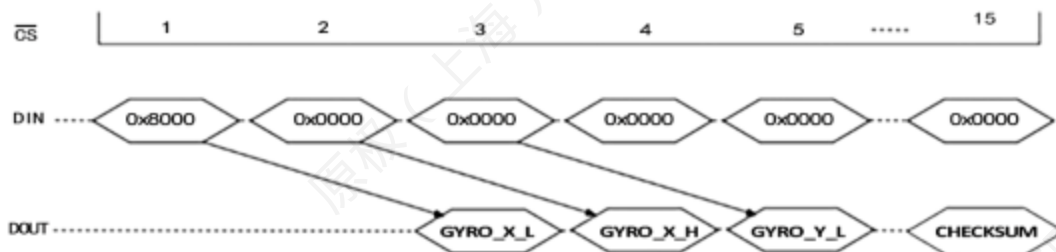


Table 32 Basic format of continuous reading by SPI BURST

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
Sending sequence	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					

Note 1: All data are 16-bit widths

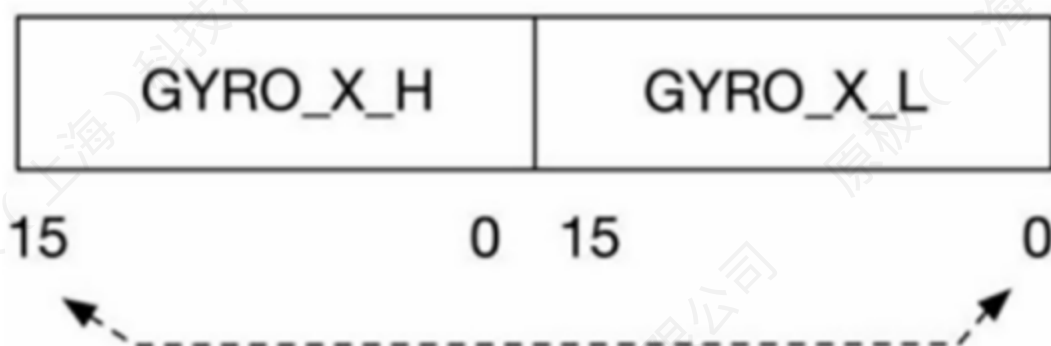


Note 2: The format of gyro and accelerometer data after concatenation is expressed as int32

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. 17 Schematic diagram of SPI32 bit data restoration



## 32-bit Gyroscope Data Format

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

Table 33 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	°C	$T = SF / 65536 * (TEMP - 172621824) + 25$	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. This register is read/write register, 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 instruction 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 is configured and the accelerometer filter is 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: 0x6A00~0x7000 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 ASCII 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 SPI WIN\_CTRL register format

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 code

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

## 8. Synchronize the time

With time synchronization, you can ensure that the internal clock of the device is consistent with the external time reference, which can eliminate the time deviation due to clock drift.

In a system with multiple devices working together, the time stamps of all devices will be based on the same time benchmark, which helps to ensure data consistency and accuracy.

At present, this module provides two methods of time synchronization:

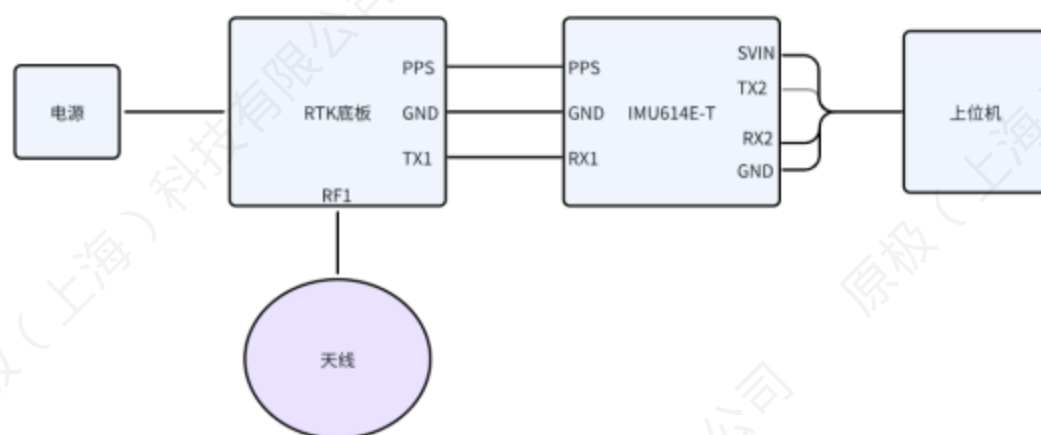
1. Access pps signal + rmc message,
2. Synchronize time on the Master using DRDY signals

## 8.1 Connecting the PPS Signal and GPRMC Packet

### 8.1.1 Hardware connection

(1) Connect the IMU to the RTK Base Plate according to the connection diagram.

Figure 18 Connecting the IMU614E-T to the RTK



### 8.1.2 RTK Configuration Requirements:

GPRMC 10HZ

Disable inertial Navigation Assistance-related functions of the RTK board Turn off other statements.

PPS second pulse: 1s once, rising edge triggered, pulse width 5ms, aligned to UTC time. High level must not be higher than 5v.

Ensure that the baud rate of the serial port on the RTK is the same as that of the IMU.

Connect the RTK Base Plate to the Master, open the serial port assistant, and input commands successively:

CONFIG (View the baud rate configuration)

config com1 115200 (corresponds to IMU baud rate)

saveconfig (save Parameter)

### 8.1.3 IMU enable time synchronization without sending instructions, ensure that the wiring harness is connected OK

### 8.1.4 How Do I Confirm the Time synchronization success?

The steps to confirm are as follows

Before synchronization, count the value of the IMU itself in ms format

After synchronization, it will become the true value after UTC conversion in ms, taking the true value 43767630ms as an example

To convert the given ms value to s:

$$43,767,630\text{ms} = 43,767.63\text{s}$$

To convert s to h, min, and s:

First, divide the number of seconds by 3600 (1h=3600s) to get the number of hours and the number of seconds remaining.

$$43,767\text{s} \div 3600 = 12\text{h}... 567\text{s (rounded)}$$

Next, divide the number of seconds left by 60 (1min=60s) to get the number of minutes and the number of seconds left.

$$567\text{s} \div 60 = 9\text{min}... 27\text{s (rounded)}$$

Collate the results:

Combine the h, min, and s from the steps above, along with the initial decimal part, to form the final UTC time representation (hhmmss.sss).

The final UTC time representation is: 120927.63

2 Depending on the IMU update rate you set, the timestamp interval will change accordingly.

For example:

When the IMU update rate is 10Hz, the corresponding timestamp interval is 100 ms.

In this case, the timestamps will be sent at a frame interval of every 10 ms to ensure synchronization with the IMU data. The following is an example

```
%time-us,accx,accy,accz,gyrox,gyroy,gyroz,temperature,roll,pitch,yaw,mx,my,mz
43767630,0.000911493,-0.00593111,-0.999837,-0.112592,0.0775201,-0.239427,37.375,0.37371,0.0374005,359.763
43767640,0.00104886,-0.00639931,-1.00023,-0.11155,0.0945329,-0.198418,37.375,0.372709,0.0378392,359.763
43767650,0.0010143,-0.00654209,-1.00144,-0.143203,0.0859424,-0.187509,37.375,0.372681,0.038661,359.763
43767660,0.000973708,-0.00638983,-1.00176,-0.166009,0.092228,-0.200648,37.375,0.372481,0.0390947,359.763
43767670,0.00147395,-0.00683136,-1.001,-0.192246,-0.00178328,-0.157266,37.375,0.372781,0.0399402,359.763
43767680,0.00223095,-0.00695176,-1.00109,-0.0757273,-0.000226222,-0.138093,37.375,0.372781,0.0399402,359.763
43767690,0.00127585,-0.00571409,-1.00053,-0.173622,0.0492768,-0.163678,37.375,0.373524,0.0425388,359.763
43767700,0.00074174,-0.00655202,-1.00021,-0.115697,0.000131873,-0.160155,37.375,0.372256,0.0430011,359.763
43767710,0.00167231,-0.00625615,-1.00077,-0.196135,-0.000426489,-0.177769,37.375,0.372131,0.0433163,359.763
43767720,0.00185977,-0.0061884,-1.00042,-0.224989,-0.0107625,-0.0937578,37.375,0.371704,0.0457214,359.763
43767730,0.00024303,-0.00667565,-1.00119,-0.252968,0.0338021,-0.143835,37.375,0.371704,0.0457214,359.763
43767740,0.000261399,-0.00675453,-1.00142,-0.221033,0.0709242,-0.198763,37.375,0.37201,0.0447791,359.763
43767750,0.000898074,-0.00627877,-1.00137,-0.146918,0.0208479,-0.177816,37.375,0.372149,0.0439286,359.763
43767760,0.00114561,-0.00632768,-1.00142,-0.116412,0.0106449,-0.195621,37.375,0.371879,0.0448294,359.763
43767770,0.00031602,-0.0065025,-1.00118,-0.151384,0.107034,-0.151737,37.375,0.371925,0.0443909,359.763
43767780,0.000111739,-0.00596614,-1.00127,-0.191872,0.0392804,-0.190575,37.375,0.371925,0.0443909,359.763
43767790,0.000446753,-0.00575444,-1.00054,-0.144282,0.0438216,-0.206097,37.375,0.371021,0.0432654,359.763
43767800,0.000744278,-0.00620892,-1.00097,-0.0806283,0.0402478,-0.2018,37.375,0.370079,0.0418417,359.763
43767810,0.000249961,-0.00627208,-1.00092,-0.205578,0.0244218,-0.173429,37.375,0.369413,0.0418069,359.763
43767820,0.2315e-05,-0.00632706,-1.00116,-0.190721,0.0747152,-0.227714,37.375,0.3691,0.0408873,359.763
43767830,0.00024524,-0.00670832,-1.00086,-0.117692,0.111822,-0.193005,37.375,0.3691,0.0408873,359.763
43767840,0.000537576,-0.00604259,-1.00108,-0.146042,0.043116,-0.178889,37.375,0.369541,0.0392609,359.763
43767850,0.00102963,-0.00625389,-1.00084,-0.165271,0.000858686,-0.146898,37.375,0.369012,0.0390227,359.763
43767860,0.00121603,-0.0058367,-1.00105,-0.207972,0.0699086,-0.172457,37.375,0.368091,0.0399286,359.763
43767870,0.00114882,-0.00628435,-1.00111,-0.192793,0.0395967,-0.177017,37.375,0.36763,0.0405705,359.763
```



## 8.1.5 How Do I Verify that the timestamp is Correct After Time synchronization

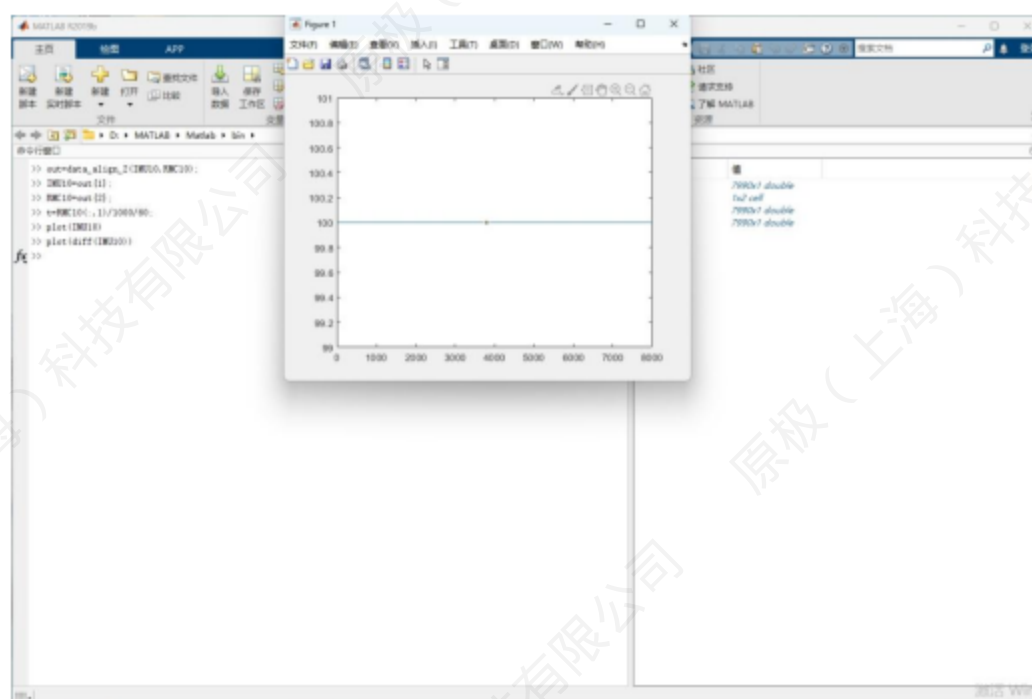
1. Collect and decode RMC data and AHRS data after time synchronization at the same time.
2. Convert the two time stamps into the same format, and use matlab and other tools to count the following indicators of the following two groups of corresponding time stamp data

First, the statistical time stamp interval is stable, confirm whether there is packet loss,

Judging conditions:

10HZ output: The interval is stable to 100ms

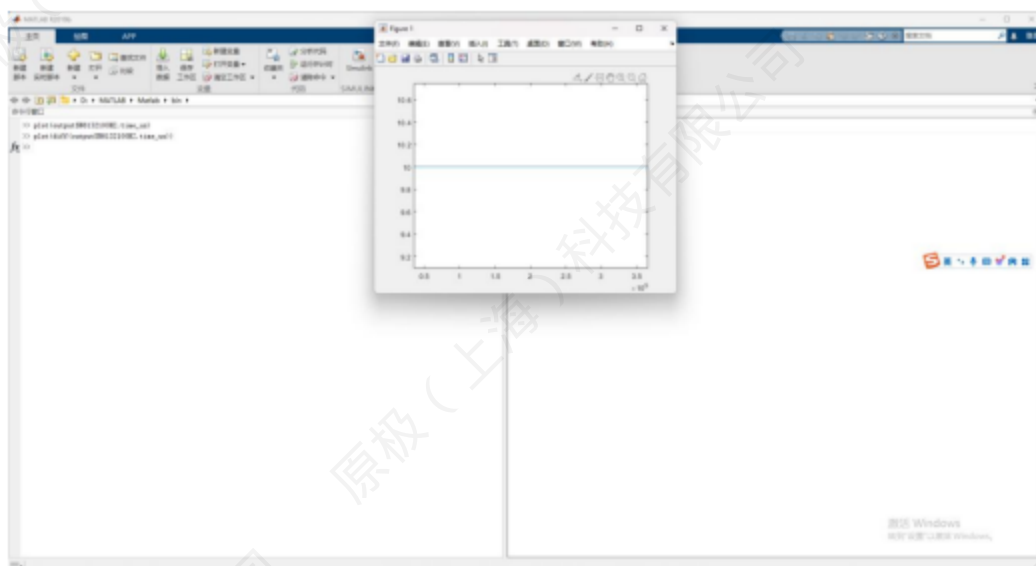
```
%time_us,accx,accy,accz,gyrox,gyroy,gyroz,temperature,roll,pitch,yaw,mx,my,mz
10138100,-0.00785668,0.000511979,-1.00068,0.00577856,0.0224228,-0.170839,43.6992,-0.185733,-0.373024,2.66486
10138200,-0.00548826,-8.32841e-06,-1.00069,0.120156,-0.0394001,0.0182559,43.6992,-0.177175,-0.373694,2.66124
10138300,-0.0177959,-0.0481571,-1.00444,-0.452245,-0.0625247,-6.75837,43.6992,-0.166894,-0.370253,2.60756
10138400,-0.00540888,-0.000368123,-0.999689,0.0587807,0.157406,-0.743163,43.7031,-0.179521,-0.368657,2.35367
10138500,-0.00681769,0.00110348,-1.00052,-0.0118609,-0.0201513,-0.0745728,43.6992,-0.174604,-0.366914,2.32512
10138600,-0.00541474,-2.34533e-05,-1.00088,0.0289074,-0.0428571,0.0164407,43.6992,-0.168918,-0.367043,2.32495
10138700,-0.00661371,0.000592246,-1.00062,0.00993176,-0.000438364,-0.0288885,43.6953,-0.163664,-0.364568,2.3255
10138800,-0.0048226,6.92813e-05,-1.00043,-0.00735649,0.0273419,-0.0158955,43.6992,-0.155855,-0.371403,2.33634
10138900,-0.00664255,0.000866315,-1.00145,0.0919172,-0.0107388,-0.0110982,43.7031,-0.151304,-0.366063,2.33678
10139000,-0.00515508,-0.000483297,-0.999668,-0.00652478,0.114841,-0.00554243,43.6992,-0.147101,-0.370124,2.3664
10139100,-0.00679933,8.07165e-05,-1.00015,0.0193778,-0.00205665,0.000614035,43.6953,-0.141752,-0.363385,2.36672
10139200,-0.00633591,0.000995697,-1.00043,0.0350645,-0.0332949,0.0570056,43.6875,-0.136313,-0.36819,2.37055
10139300,-0.00676747,0.000319971,-1.00062,0.0243442,0.0444976,0.00981862,43.6875,-0.133467,-0.362919,2.37656
10139400,-0.00663674,0.000352815,-1.00029,0.00787024,0.0201864,-0.00876646,43.6953,-0.129017,-0.368695,2.37739
10139500,-0.00679523,0.00118807,-1.00101,-0.00626396,-0.0206355,-0.00567084,43.6953,-0.12762,-0.359295,2.37722
10139600,-0.00583052,8.28852e-05,-0.99977,0.0120336,0.0297521,-0.00074564,43.6992,-0.122915,-0.366905,2.37741
10139700,-0.00690794,0.000215317,-1.00052,0.000730211,-0.0126271,-0.0145498,43.6992,-0.116187,-0.361241,2.37884
10139800,-0.00553715,0.000524005,-1.00127,0.0570455,-0.014946,0.0273024,43.6992,-0.109288,-0.369261,2.37931
10139900,-0.0059149,5.67176e-05,-1.00066,0.00898911,0.0247195,0.0501371,43.7031,-0.100622,-0.362934,2.39978
10140000,-0.00614014,-5.688e-06,-1.0002,-0.121098,0.0651305,-0.00916049,43.707,-0.100607,-0.366901,2.41725
10140100,-0.00616532,-0.000320024,-1.00114,0.0116914,0.00976389,-0.00659498,43.707,-0.0948647,-0.361206,2.41734
10140200,-0.00566859,-0.0003737,-1.00026,-0.00623558,0.013495,0.00671942,43.707,-0.0888662,-0.36321,2.41761
10140300,-0.00680167,-8.83485e-05,-1.00077,-0.100855,0.0120432,-0.00189858,43.707,-0.0788807,-0.362496,2.41875
```



IMU10HZ

100HZ output: The interval is stable at 10ms

```
%time_us,accx,accy,accz,gyrox,gyroy,gyroz,temperature,roll,pitch,yaw,mx,my,mz
12168590,-0.000783923,0.00227535,-0.999381,0.0285426,0.143975,0.0399726,45.8711,-0.261506,-0.0423138,0.597821
12168600,-0.00109725,0.00241267,-1.0014,0.00518191,-0.0503187,-0.0185507,45.8711,-0.260736,-0.0420368,0.598055
12168610,-0.000684899,0.00193684,-1.00129,0.0177225,-0.0174652,-0.00366374,45.875,-0.260757,-0.0421491,0.597998
12168620,-0.00110074,0.00186692,-0.999633,-0.0096959,-0.0503915,-0.0200717,45.8789,-0.259998,-0.0419311,0.597955
12168630,-0.00106939,0.00180071,-0.999801,-0.0493901,0.0672579,0.0065974,45.8789,-0.259534,-0.0427631,0.59775
12168640,-0.0012183,0.00200934,-1.00052,-0.0110379,0.0375103,-0.0019704,45.8789,-0.259273,-0.0431737,0.59775
12168650,-0.0014417,0.00172895,-0.999741,0.00149567,-0.0142063,0.00627559,45.8789,-0.259389,-0.0429253,0.597709
12168660,-0.00050238,0.00208577,-1.00103,-0.0168498,-0.0534377,-0.0177292,45.8789,-0.258919,-0.0438387,0.597691
12168670,-0.000328396,0.0019613,-1.00188,-0.00600252,0.0650926,0.0114503,45.8789,-0.258381,-0.0436349,0.597619
12168680,-0.000636144,0.00222931,-0.99907,-0.0270124,0.0734599,-0.000431323,45.8789,-0.258442,-0.0435879,0.597725
12168690,0.000112191,0.00221846,-1.00066,0.0151018,-0.056569,0.0147384,45.8789,-0.258043,-0.04342,0.597736
12168700,-0.000231573,0.00266871,-1.00237,0.00901595,-0.0218375,0.00337262,45.8789,-0.257449,-0.0417969,0.597825
12168710,8.72014e-05,0.00254247,-0.999538,0.0329301,-0.00658109,0.0136745,45.8789,-0.257216,-0.0417704,0.598
12168720,0.00029099,0.00226171,-1.0001,0.0078541,0.0694334,0.000107848,45.8789,-0.256338,-0.0408185,0.597988
12168730,0.000775636,0.00183092,-1.00108,-0.00733744,-0.0481737,-0.00525246,45.8789,-0.255627,-0.038995,0.597951
12168740,0.000808696,0.00174323,-1.00027,0.0295915,0.00286059,-0.0054113,45.8789,-0.25467,-0.0370789,0.598049
12168750,6.85134e-05,0.00170626,-0.999359,-0.0195651,0.0255302,0.0089159,45.8789,-0.254544,-0.0368456,0.597978
12168760,0.000233264,0.00187571,-1.00239,-0.0111067,0.0395717,-0.0164223,45.8789,-0.2539,-0.0362479,0.597931
12168770,0.000169324,0.00123586,-0.998619,-0.0318644,-0.0207638,0.0203835,45.8789,-0.253344,-0.0350068,0.59792
12168780,0.00034488,0.000749115,-0.999338,-0.0227521,0.00308496,-0.0240282,45.8789,-0.253686,-0.0353146,0.597991
12168790,0.000321285,0.0015652,-1.00105,-0.00523137,0.00901491,-0.0121445,45.8789,-0.253063,-0.0340612,0.597738
12168800,-0.000715598,0.0026208,-1.00151,0.0337185,0.0201632,0.00606421,45.8789,-0.252559,-0.0335472,0.597631
12168810,-0.000791669,0.00262174,-0.999473,0.0266765,0.0124253,-0.00269134,45.8789,-0.25235,-0.0333288,0.597486
```



IMU100HZ

2. Check whether the time difference is 0 under the same output frequency of the two sets of corresponding timestamp data (in the case of good satellite condition)

The following is a statistical example:



4	10147500	10147500	0
5	10147600	10147600	0
6	10147700	10147700	0
7	10147800	10147800	0
8	10147900	10147900	0
9	10148000	10148000	0
10	10148100	10148100	0
11	10148200	10148200	0
12	10148300	10148300	0
13	10148400	10148400	0
14	10148500	10148500	0
15	10148600	10148600	0
16	10148700	10148700	0
17	10148800	10148800	0
18	10148900	10148900	0
19	10149000	10149000	0
20	10149100	10149100	0
21	10149200	10149200	0
22	10149300	10149300	0
23	10149400	10149400	0
24	10149500	10149500	0
25	10149600	10149600	0
26	10149700	10149700	0

IMU10HZ

1	12174500	12174500	0
2	12174600	12174600	0
3	12174700	12174700	0
4	12174800	12174800	0
5	12174900	12174900	0
6	12175000	12175000	0
7	12175100	12175100	0
8	12175200	12175200	0
9	12175300	12175300	0
10	12175400	12175400	0
11	12175500	12175500	0
12	12175600	12175600	0
13	12175700	12175700	0
14	12175800	12175800	0
15	12175900	12175900	0
16	12176000	12176000	0
17	12176100	12176100	0
18	12176200	12176200	0
19	12176300	12176300	0
20	12176400	12176400	0
21	12176500	12176500	0
22	12176600	12176600	0
23	12176700	12176700	0

IMU100HZ

## 8.2 Do time synchronization on the host using DRDY signal signals

### 8.2.1 DRDY Signal Function

In an IMU, the DRDY (Data Ready) signal is an important status marker or interrupt signal used to indicate that the IMU's data is ready and can be read. When the IMU completes a round of data acquisition and processing, the DRDY signal will become active (usually low), which means that the new acceleration, Angular velocity and other data are ready to be read.

After the Master is connected to the IMU, it can determine the exact moment when the data is ready by detecting the clock synchronization signal from inside the IMU provided by the DRDY, and add a time stamp and parse the data at that moment. This means that whenever the DRDY signal changes, the Master knows that the data is ready and can record the time at this time as a timestamp for that data.

### 8.2.2 How do I turn on the DRDY signal

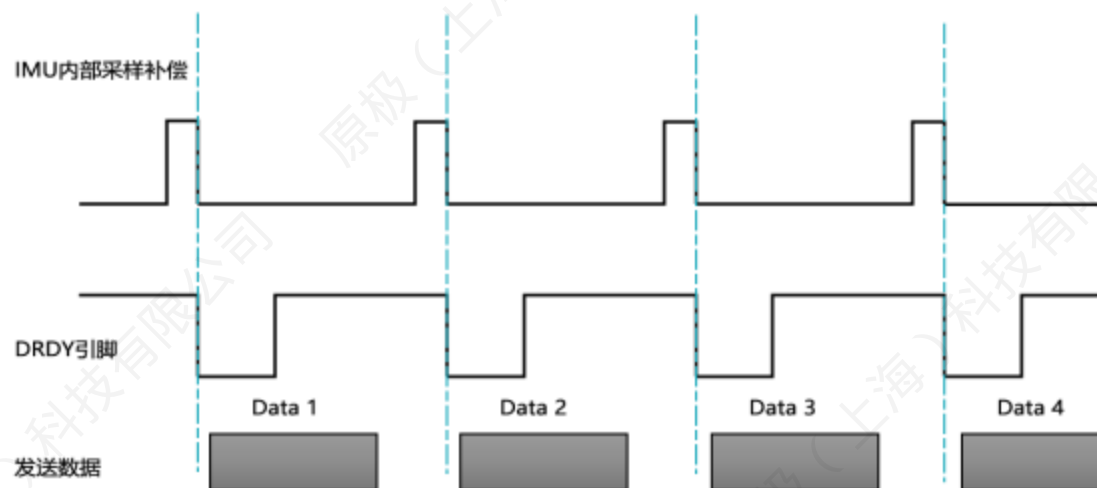
After most products are upgraded through the Upper computer software COM, DRDY is on by default (currently, DRDY of P8MINI, IMU470, and IMU16460 is off by default, and the subsequent firmware will be set to on by default). If DRDY is off after the product is upgraded through the COM, after the Upper computer software can read the parameter table, Change the 39th Parameter in the Parameter table to the value 100. If the customer needs to enable the DRDY function when using the firmware of an earlier version, he can use the command generator on the Upper computer software to input the following Parameter and send the command to enable the DRDY function. If you burn through the burner, the DRDY function is turned on by default.

### 8.2.3 DRDY Signal

DRDY Pin output serves two purposes:

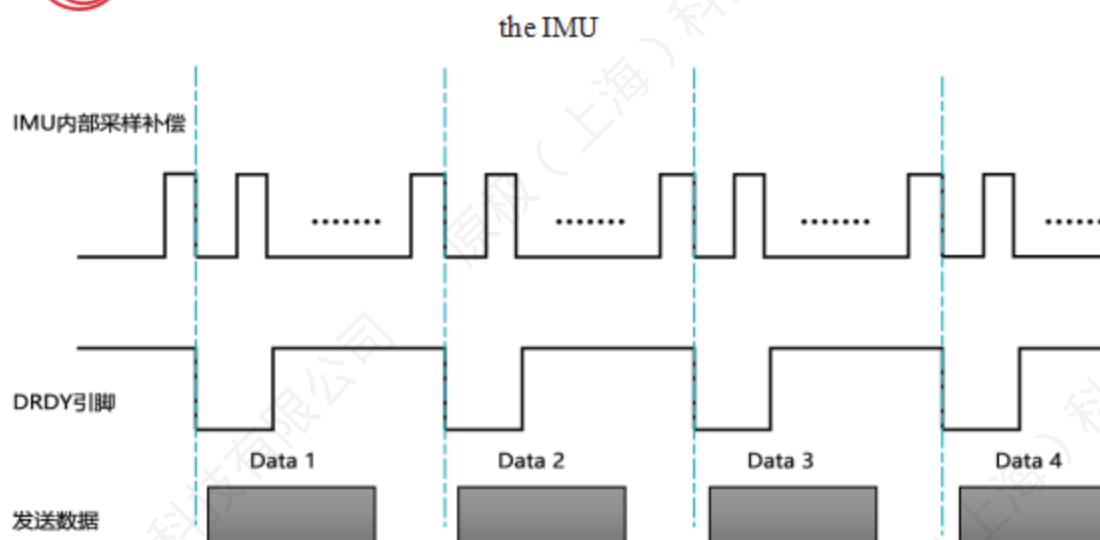
1. to provide a clock synchronization signal from inside the IMU; How to
- 2 Provide a signal to start transmitting data frames.

FIG. 19 internal sampling frequency is consistent with the serial output frequency



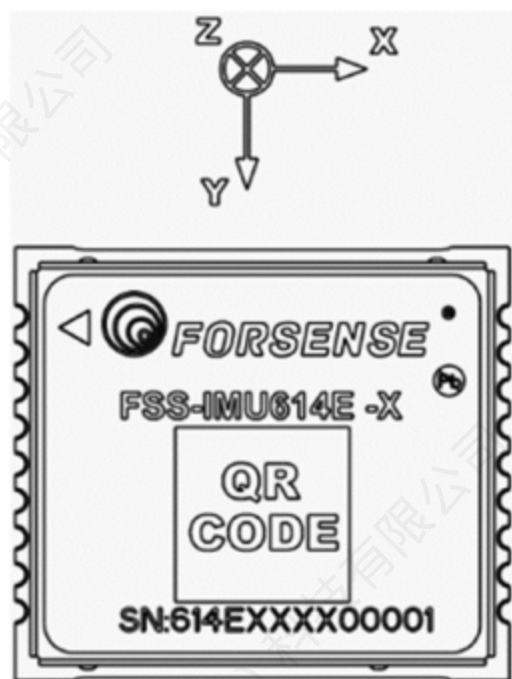
When the internal sampling frequency of the IMU (maximum ODR) is consistent with the serial output frequency (current ODR), the DRDY pin will be pulled down immediately after the completion of imu data sampling compensation, at which time the data frame will be sent from the serial port, and the DRDY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

FIG. 20 The output frequency of the serial port is less than the internal sampling frequency of



## 9. Definition of coordinate system

Figure 21 Definition of coordinate system



The product coordinate system uses the forward-right-down (FRD) coordinate system, and the Euler Angle range is as follows:

Rotation around the Z axis: Yaw angle Yaw range:  $0^{\circ} \sim 360^{\circ}$

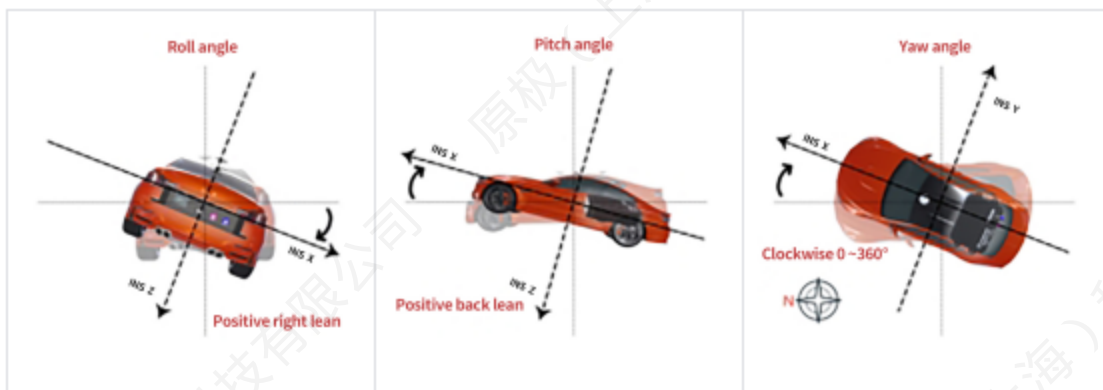
Rotation around the X axis: Roll Angle Roll range:  $-180^{\circ} \sim 180^{\circ}$

Rotation around the Y-axis direction: Pitch Angle range:  $-90^{\circ}$  to  $90^{\circ}$



Roll, pitch, course Angle diagram is as follows:

FIG. 22 Schematic diagram of roll, pitch and Yaw 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	
Coordin ate system	Schematic diagram	Coordin ate system	Schematic diagram	Coordin ate system	Schematic diagram
106		114		122	
107		115		123	
108		116		124	

Synchro

document:

<https://xvb5yklhnf.feishu.cn/docx/Xqd2d3kJ5otGuaxrEIQcARicnlf#DuMldUiN1sASvPb52gScqrZhn nf>



## 10. CRC table lookup method

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

```
static const uint32_t crc32_tab[] = {
    0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419, 0x706af48f,
    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, 0xdcdcd0cf, 0xabdd13d5,
    0x26d930ac, 0x51de003a, 0xc8d75180, 0xbfdb06116, 0x21b4f4b5, 0x56b3c423,
    0xcfb9a599, 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,
    0x8bbbeb8ea, 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, 0x8eb9eff9, 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, 0x0bdbbdf21, 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, 0xdeb9ec5, 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;
}

```

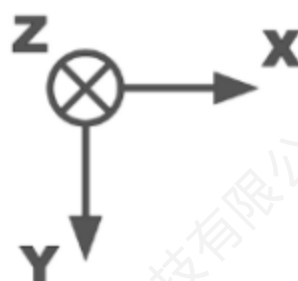


## 11 Use examples

### 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.

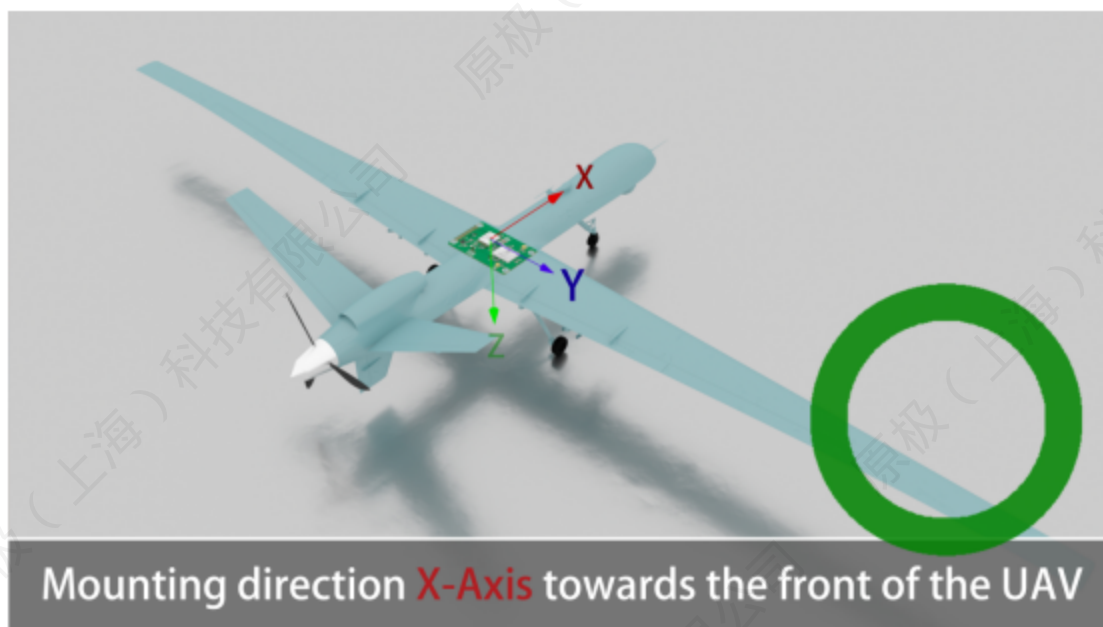
Figure 23 Schematic diagram of module installation



The correct installation diagram is as follows

The X axis faces the front of the car

Figure 24 Diagram of proper installation



The following installation methods are incorrect installation

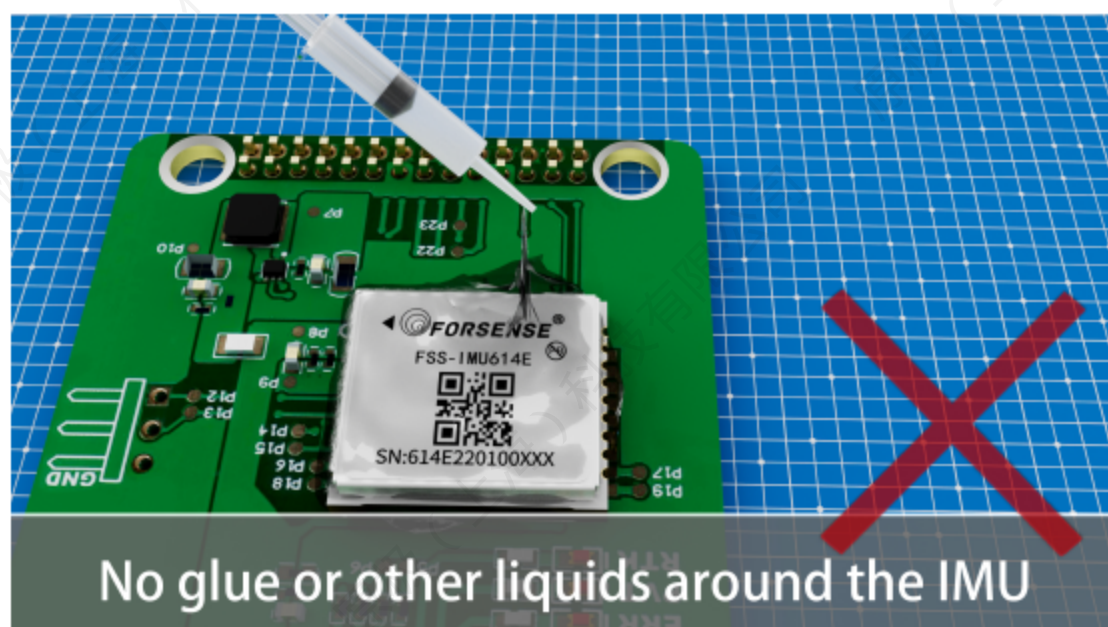




### 3. Precautions for IMU installation

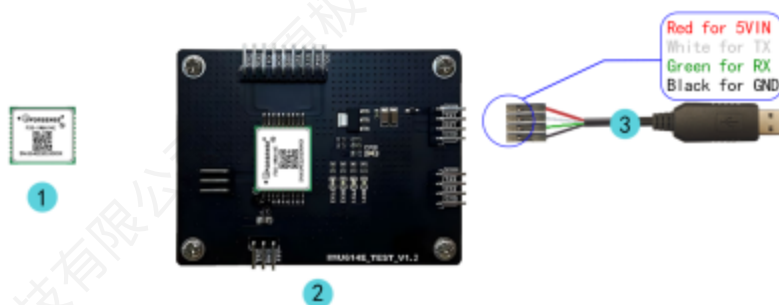
Do not use glue or other flowing liquid around the IMU to prevent liquid from flowing into the IMU through gaps and affecting the IMU performance.

Figure 25 Schematic diagram of incorrect installation

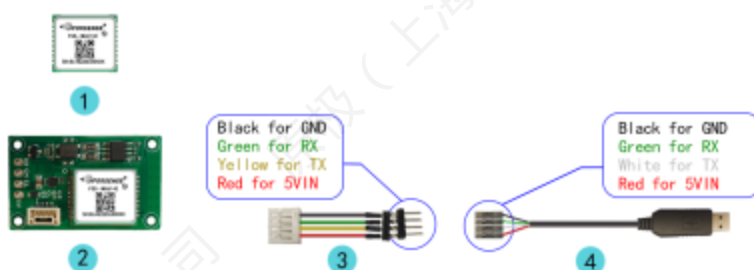


## 11.2 Example for Connecting a Upper computer software

FIG. 26 Schematic diagram of module connecting to Upper computer software



	Name	Quantity
1	IMU 614E Series Module	1
Accessories Name		Quantity
2	IMU614E Test Substrates	1
3	TTL Serial Cable	1



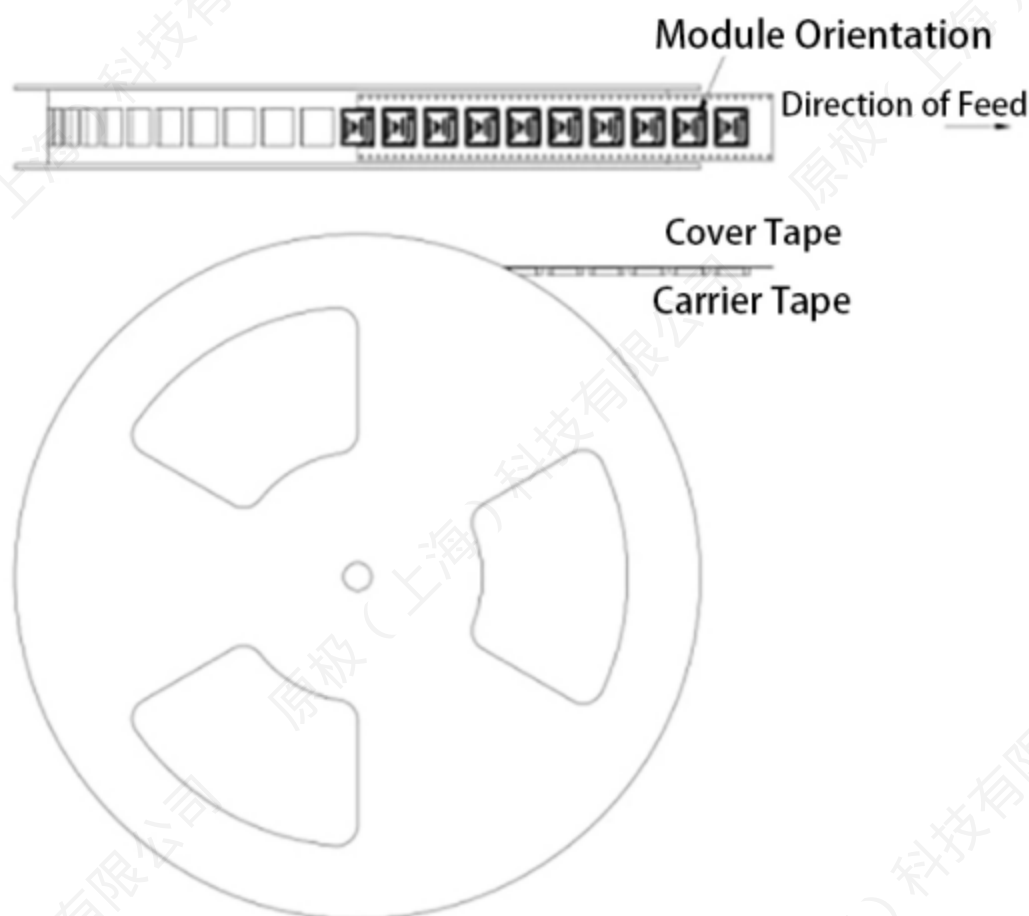
	名称	数量
1	IMU614E系列模组	1个
附件名称		数量
2	TTL版本测试底板	1个
3	4-PIN接头	1个
4	TTL串口线	1个

## 12. Packaging

The IMU614E-T module is packaged in a tape seal. For efficient production.

### 12.1 Roll and tape packaging

Figure 27 Schematic diagram of reel and tape packaging



Reel Size: 13inch (OD 330 x ID 100 x Thickness 37mm)

## 12.2 Carrier Tape

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

Figure 28 Position and direction of the IMU614E-T on the load belt



### 13. Select accessories



IMU614E-X Tests Base Plate (old Base Plate) IMU614E-X Tests Base Plate (new Base Plate)



Patch CAN Version IMU614E Series Patch 485 version IMU614E Series



Patch TTL Version IMU614E Series TTL serial cable



USB to CAN module Type-c cable



Versions	Dates	Status/Comments
Version 1.0	2024.11.26	First Edition