FORSENSE
原极科技

Tactical MEMS
6 degrees of freedom inertial sensor

FSS-IMU614E-S Product manual

Features

100% pure domestic

Tactical grade MEMS gyroscope

I 3.0°/hr zero bias instability

I 0.15°/√ hr Angle random walk

Tactical grade MEMS accelerometer

I 35μg zero-bias instability

I 0.04m/s /√hr velocity random walk

Independent turntable calibration

I Independent calibration of each module: sensitivity, zero bias, non-orthogonal error

I-40 ° C to 85 ° C temperature compensation

High strength condition tolerance

I Super impact tolerance: 2000g (0.5ms, half sine, 3 axis)

I Strong vibration resistance: 10g (10~2KHz, 3 axis)

I Full temperature environment stable operation: -40℃ ~ 85℃

I 100% magnetic shielding

Real-time and flexible digital interface, small size

I Configurable output sampling rate up to 1kHz

I Support serial port, I2C, SPI multiple interfaces

I 14.7*17*3.2mm, weight only 1.6g

Product Overview

FSS-IMU614E-S is a 6-DOF MEMS inertial sensor module built by the original pole technology, with the standard output of three-axis gyroscope and acceleration information. This model

The IMU adopts **an all-domestic scheme**. Both sensing

The device, the processor, and the software algorithm all adopt the **localization scheme**.

High precision, high resolution, can capture subtle vibration and tilt. All modules are benchmarked before leaving the factory, so that each module can be stable in a variety of extreme conditions, while ensuring a high degree of consistency in performance across all products.

Application areas

IMU application scenarios with **localization requirements**, such as:

- Attitude and Heading Reference System (AHRS)
- Platform stabilization system
- Industrial robot

On the basis of standard performance and output parameters, Yuanji also provides **customized software and software** for your special needs

LOGO customization service, in the product to help you in the arm!

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
Zero bias instability 1	@25 ° C,ALLAN variance, 1σ		3		°/hr
Zero bias stability	National military standard, 10s smooth		15		°/hr
Zero bias repeatability	National Army mark		50		°/hr
Resolution			0.0153		°/s
g value sensitivity			/		°/h/g
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		34		Hz
ODR			100	1000	Hz
Full temperature range zero deviation variation	-40 to 85 ° C, <=1 °C/min@1σ		0.2		°/s
Random Walk	@25 ° C,ALLAN variance, 1σ		0.15		°/√hr
Calibration coefficient error			XY:4 Z:2		‰
Scale coefficient nonlinear	@ 25 °C		100		ppm

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

1.2 Accelerometer Key indicators

Table 2 Key indicators of accelerometer

Parameters	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			Plus or minus 8		g
Zero bias instability 1	@25,ALLAN variance, 1σ		35		Mu g
Zero bias stability	National military standard, 10s smooth		150		Mu g
Zero bias repeatability	National Army mark		2		mg
Resolution			0.244		mg
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		34		Hz
ODR			100	1000	Hz
Full temperature range zero skewing	-40 ~ 85℃, <= 1℃/min @ 1 sigma		3		mg
Random Walk	@25 ° C,ALLAN variance, 1σ		0.04		m/s/√hr
Calibration coefficient error			0.5		‰
Calibration coefficient nonlinearity	@ 25℃		200		ppm

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

Figure 1 Typical curve of ALLAN variance for gyroscope

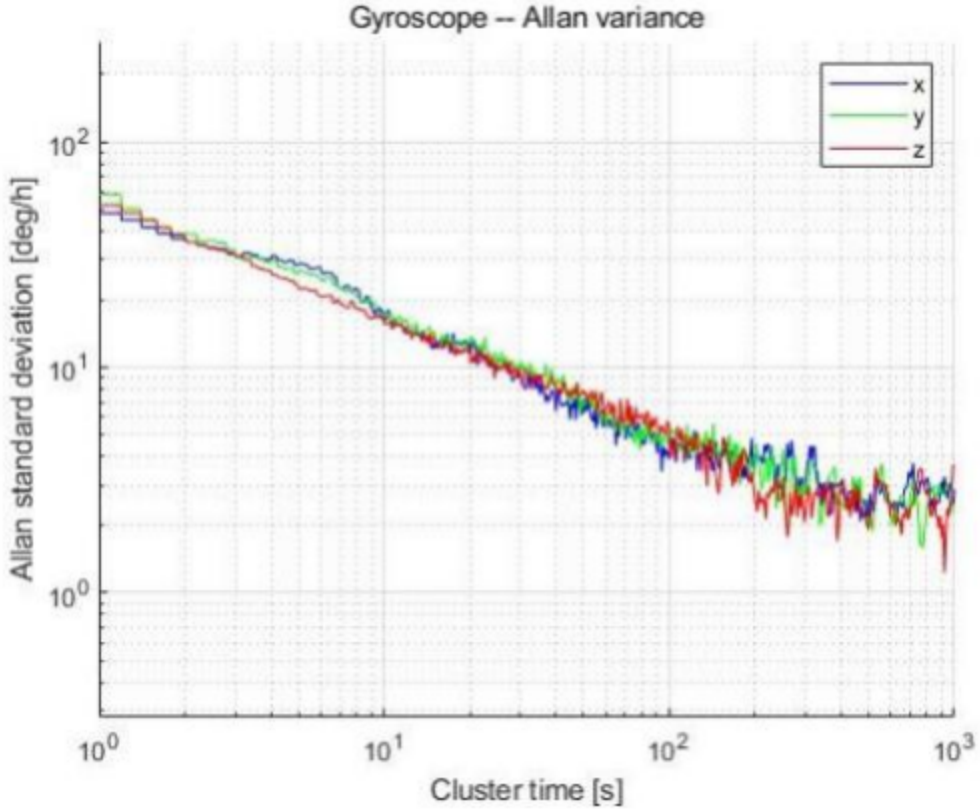
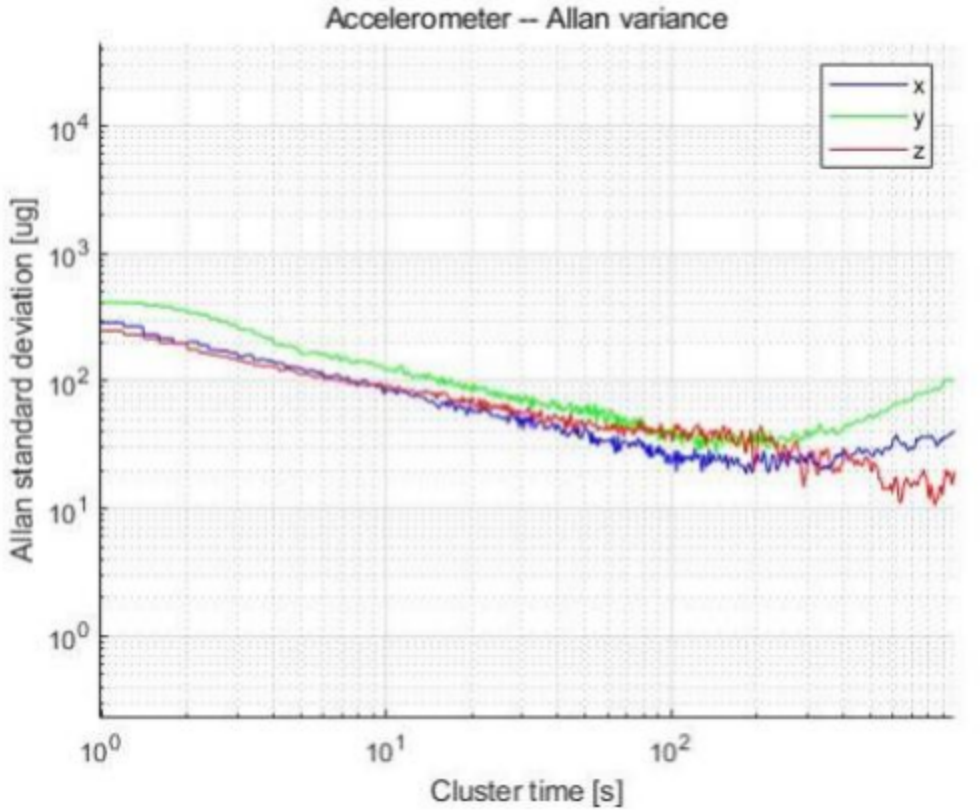


FIG. 2 Typical curve of ALLAN variance for accelerometer



1.3External

Structure

Figure 3 External structure and dimensions (unit: mm)

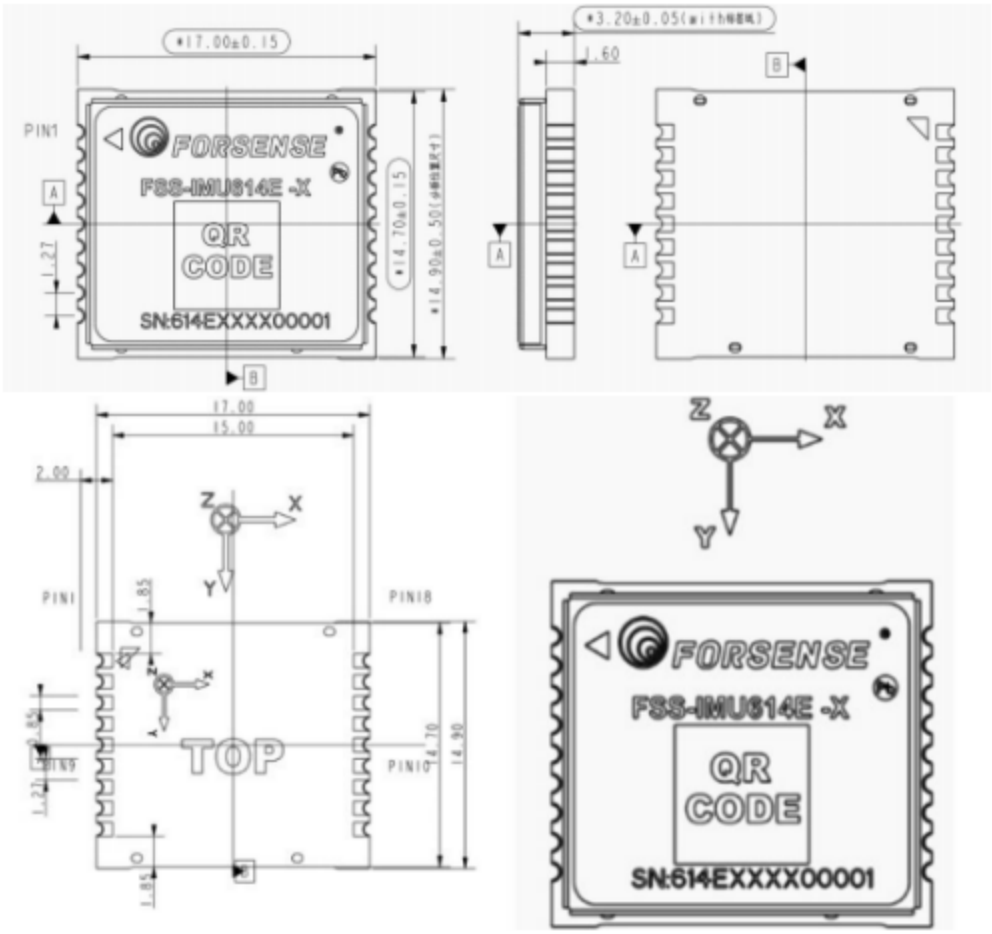
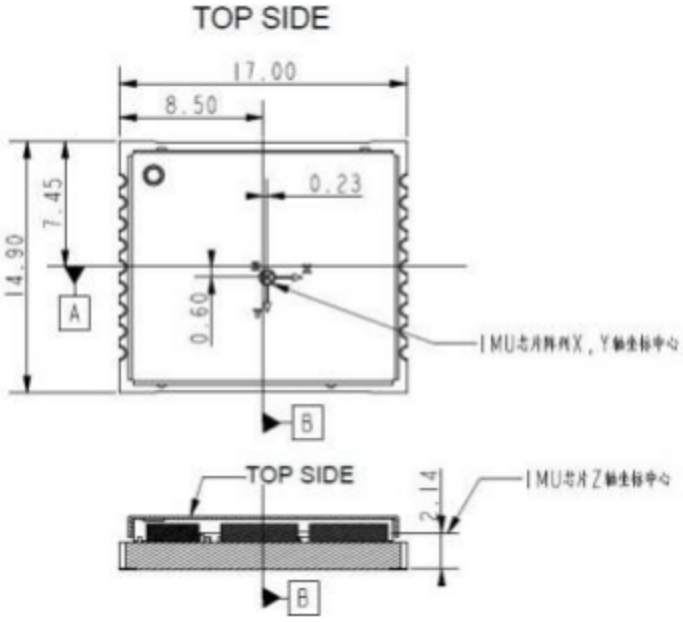


Figure 4 Coordinate center of IMU (unit: mm)



2 Electrical characteristics

2.1 Maximum tolerance value

Table 3 Maximum absolute rating

argument	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
Use temperature	Tot	-40 to 85	℃
Storage temperature	Tstg	-40 to 85	℃

2.2 Working Conditions

Table 4 Working conditions

Parameters	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		0.12		W
Use temperature	T	-40		85	℃
Storage temperature	T	-40		85	℃

2.3 I/O Threshold Features

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	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

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: 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.

4 Recommend welding furnace temperature curves

Figure 6 Welding furnace temperature curve

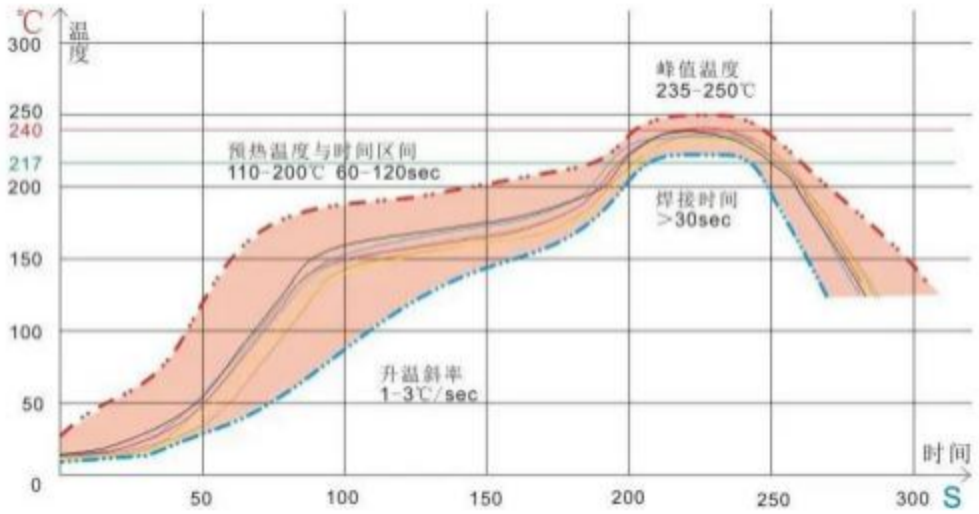


Table 7 Temperature setting mode

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 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 warping, extrusion, air welding and poor soldering due to deformation of the motherboard during reflux at high temperature.

3. Because there are sensitive devices in the module, the maximum temperature of the reflow welding machine used by the customer should not exceed 260℃ (refers to the package

Body surface measurement of top of package temperature).

4. It is recommended to use lead-free wash 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 reduced due to the secondary reflux;

6.Cooling:

• Controlled cooling slope to prevent negative welding effects (solder joints become more brittle) and mechanical stress inside the product, controlled cooling to help achieve bright welding surface effect, fine crystalline particles and low contact Angle, avoid fast

Cooling changes cause warping of the shield cover.

7 Check for 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;**

5 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, work tables, 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).
- Packaging and PCB must be qualified anti-static material.

6. Communication protocols

6.1 Serial Communication protocol

Examples of serial port protocols based on QT, ROSand 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 dataata fixedfrequency;

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.

6.1.1 Serial Port Parameters

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

6.1.2 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 low bit of the frame ID forserial comunication

3		ID high byte	The high byte of the serial port frame ID
4	uint16	Data length low	The low byte of the frame length for serial communication, length is the number of bytes carried by payload, that is, n

5		Data Length High	High byte of frame length for serial communication, length is the number of bytes carried by the payload, that is, n
6	uint8	Payload (n bytes)	Data load
6+n	Uint32	CRC_CEHCK (32-bit data low byte)	CRC check
7+n		CRC_CEHCK (Low byte in 32-bit data)	
8+n		CRC_CEHCK (High byte in 32-bit data)	
9+n		RC_CEHCK (32-bit data high byte)	

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

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

6.1.3 Data Flow frame -- AHRS data

Table 10 String port AHRS data format

	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 String port A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	Mus	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

6.1.4 Command Mode GET Output - System status

Table 12 Serial port 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

Table 13 String 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 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

6.1.5 Command Mode GET Output - Read parameters

Table 14 Serial port parameter input data format

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

Table 15 Serial port parameter output data format

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

Table 16 String port P load data format

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

Table 17 String port P load parameter index table

Param3	Param1	Units
3	Serial port output 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 deviation calibration result, GYRO_X_OFF	°/s
9	Y-axis GYRO zero bias calibration results, GYRO_Y_OFF	°/s
10	Z-axis GYRO zero bias calibration result, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, define the same SPI FILTER_CTRL table	

6.1.6 Command Mode SET Instruction

Table 18 Serial port input command format

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

Note 1: CMD and R1, see the R1 Load Parameter Index table

Table 19 String port R1 load data format

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

Table 20 String port R1 Load parameter index table

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 to disable data stream mode and enter COMMAD mode
5	0	0	Save the current parameter to FLASH
6	0	<value>	Read parameters, value is the index of the parameter to be read, that is, p.dex, see crosstalk 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 serial port, set value=3. For example, to read the internal filter, set value=31. For example, to read the coordinate system direction, set value=4
9	0	0	Perform a software reboot

14	<value>	3	Set the serial output baud rate, which is valid in bps value: 115200, 460800, 921600, 1500000 If value is any other value, the baud rate is set using 115200bps by default. The setting takes effect only after the system restarts. Procedure for setting the baud rate with no 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 correspondence between output frequency and serial baud rate 1000Hz: 921600bps 500Hz: 460800bps 250Hz: 460800bps 200Hz: 460800bps 100Hz: 115200bps
14	<value>	31	Internal filter configuration, defined with SPI accelerometer and gyroscope filter configuration, default 0xBB, that is, 47Hz
14	<value>	4	Set the orientation of the IMU coordinate system The value ranges from 101 to 124. See Table 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 command generator function of the host computer can be used to generate corresponding commands and send them. For the usage method, see the upper computer operation 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 Enabling AHRS output

6.1.7 Command Mode Output - User command response

Table 21 Setting parameters serial port response data format

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

Table 22 Reserved parameters Serial port response data format

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

Table 23 Serial user command response data format

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

Example: Set the serial output baud rate to 115200

Input data:
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, 00,00,00,56,2 B, 4 d, 93
Response data: AA 55 3D 75 04 00 34 75 03 00 A7 98 2A

54 Set the periodic AHRS dataoutput 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 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 the FLASH

Input 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 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

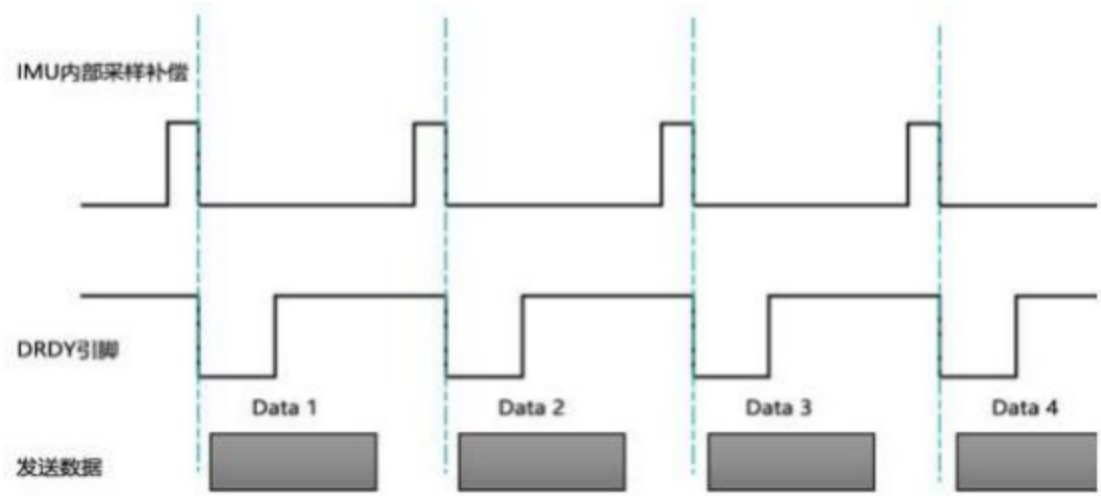
Input data: 55 AA 03 00 18 00 00 00 00 80 3F 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 52 D8 8E E8

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

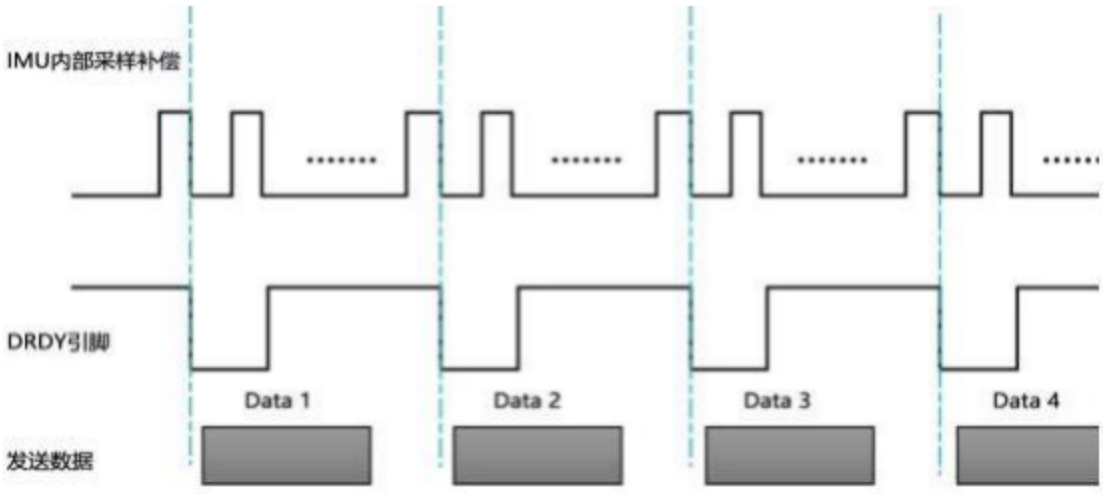
6.1.8 DRDY

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.



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.

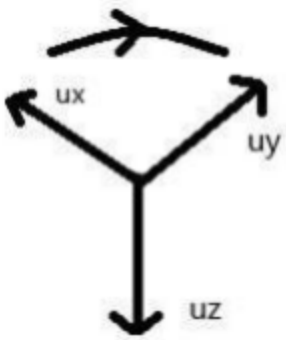


When the output frequency of the serial port is less than the internal sampling frequency of the IMU, the DRDY pin will be immediately pulled down according to the frequency divider value (maximum ODR/ current ODR) whenever the imu data sampling compensation is completed. After the DRDY is pulled down, 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.

6.1.9 Coordinate system setting function

Set the firmware coordinate system and display the corresponding firmware design coordinate system in the upper computer FIG. 8 Firmware original coordinate system



According to the rules in the figure above, when 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 serial assistant or program array and sent to the IMU.

Figure 9 CMD command on the host computer

How to read the coordinate system orientation:

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

Figure 10 Send to IMU

Example: Set the coordinate

system to 115 towards the

input data:

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

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

Refer to Table 20 to parse the parameter index

as 04, set the successful read 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 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 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

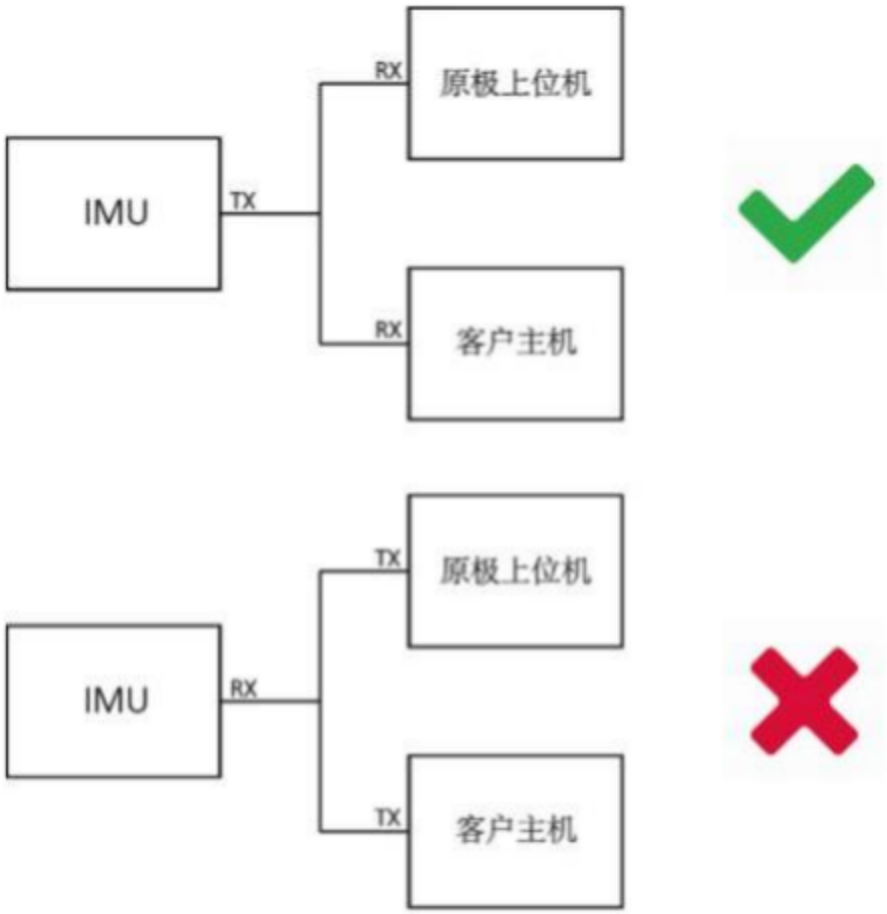
6.1.10 Serial Port Connection FAQs

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. Therefore, if the primary host needs to be connected to the PC, disconnect the communication between the PC and the serial port of the user host. Otherwise, the PC can only receive data but cannot send commands to the IMU.

As shown in the following picture:

Figure 11 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 an FT232 data line, use the system administrator to open the upper computer and automatically configure serial port delay manually configure serial port delay in the device manager.

6.2 I2C Communication Protocol

Example of I2C host read driver based on STM32:

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

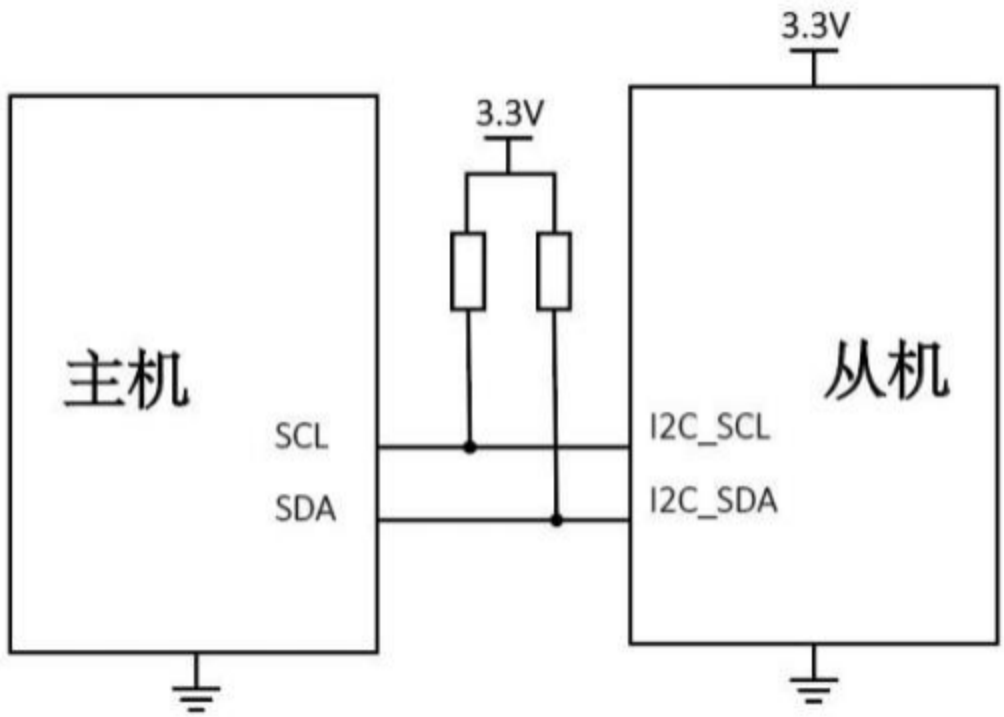
6.2.1 I2C interface Parameters

Table 25 I2C interface parameters

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

6.2.2 I2C Connection Method

Figure 12 I2C connection method



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

6.2.3 I2C Register

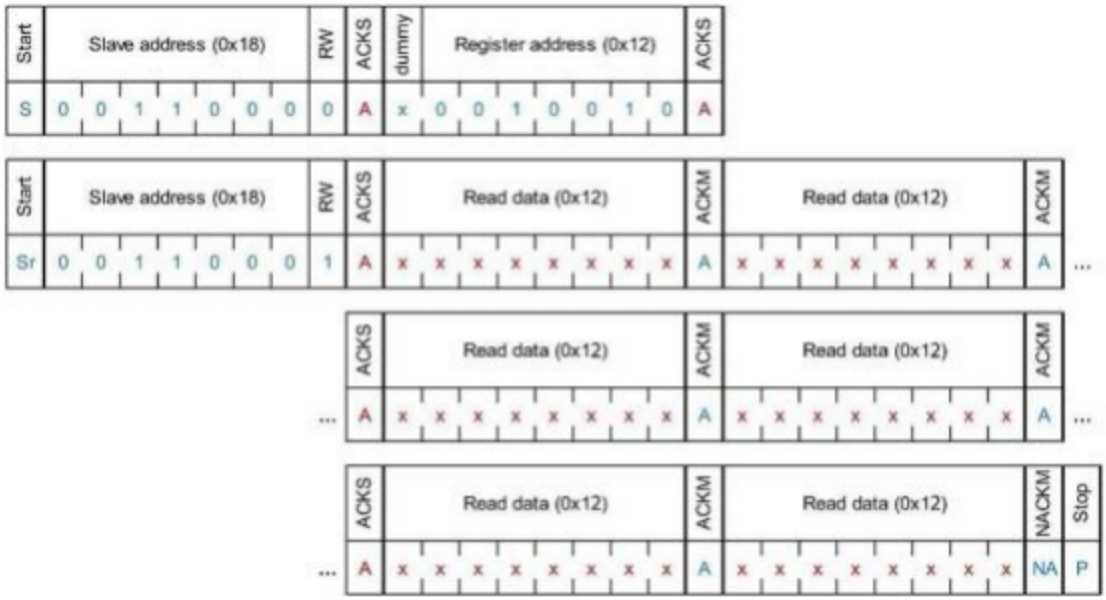
Table 26 List of I2C registers

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

6.2.3.1 I2C BURST Register

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

FIG. 13 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

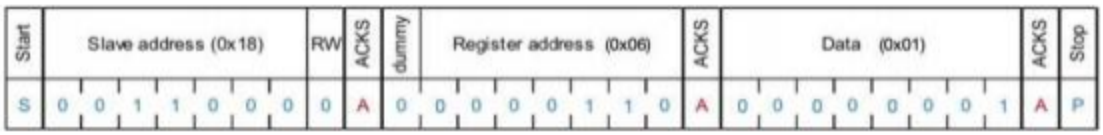
Note 1: The unit of TEMP is °C, the unit of gyroscope output is °/s, the unit of accelerometer output is g, and the unit of attitude output is degree

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.

6.2.3.2 I2C FILTER_CTRL register

The address of the FILTER_CTRL register is 0x06. The filter configuration mapping table is the same as that of the SPI accelerometer and gyroscope filter.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 14 I2C FILTER_CTRL register writing method



6.2.3.3 I2C ID register

The ID register address is 0x6A, and the data content is IMU61B in the ASCII format. The reading process is the same as 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

6.3 SPI Communication Protocol

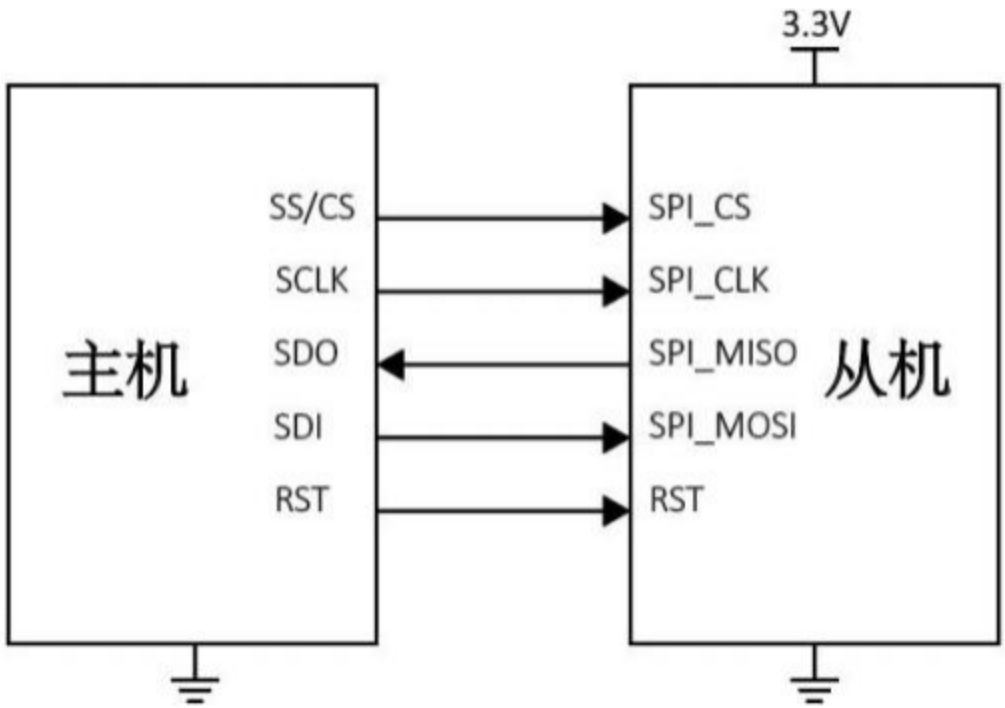
6.3.1 SPI interface parameters

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

6.3.2 SPI connection diagram

Figure 15 SPI connection diagram

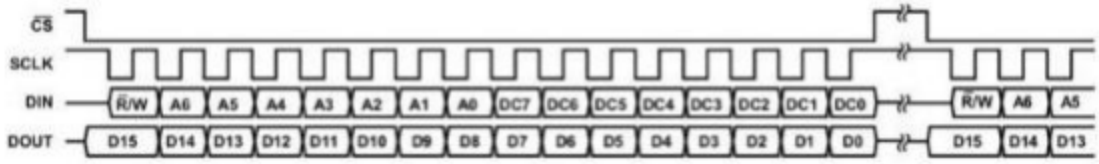


Note 1: Before the initial reading, the IMU needs to be reset and wait for 3s,so that the IMU can enter the normal working state.

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

6.3.3 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 16 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 for 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.

6.3.4 SPI register

Table 30 List of SPI registers

Names	Address	Read/Write	Default value	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	Low temperature 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	Addtable X axis height bytes
XACCEL_LOW	0x20	R	\	0	Addtable X axis low byte
YACCEL_HIGH	0x22	R	\	0	Addtable Y-axis height bytes
YACCEL_LOW	0x24	R	\	0	Addtable Y-axis low byte
ZACCEL_HIGH	0x26	R	\	0	Addtable Z-axis height bytes
ZACCEL_LOW	0x28	R	\	0	Addtable Z axis low byte

6.3.4.1 SPI BURST register

BURST is a continuous read register that reads all data in one data stream without stopping between each 16-bit segment. Table 31 Format of SPI BURST register.

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

Figure 17 Schematic diagram of continuous reading of SPI BURST

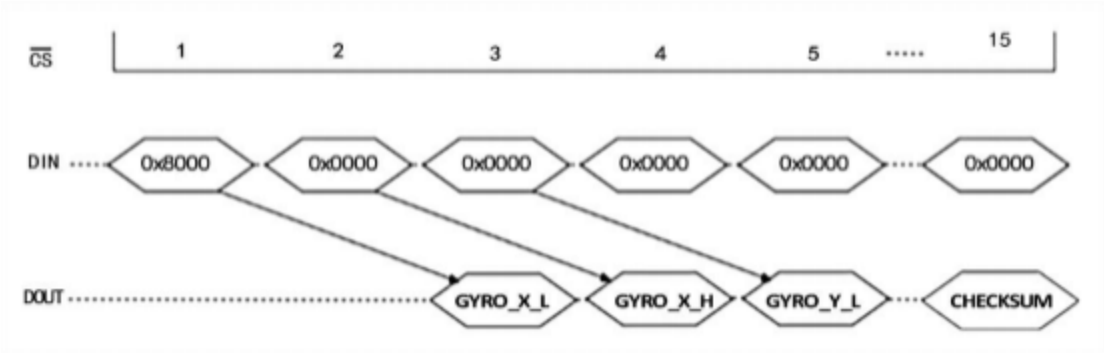


Table 32 Basic format of continuous reading by SPI BURST

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
Send order	7	8	9	10	11	12
What to	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H	ACCL_Z_L	ACCL_Z_H

send						
Sending sequence	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. The CHKSM is calculated by adding all the data before the CHECKSUM

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

FIG. 18 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 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 • For Burst mode, SF = 0.2 • For 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

6.3.4.2 SPI FILTER_CTRL register

The FILTER_CTRL register provides the user with control over the digital low-pass filter. This register is 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 is configured and the accelerometer filter is 10Hz, thevalue 0x8644 is written.

6.3.4.3 SPI ID register

The ID register is a read-only register, and the data content is the character "IMU" in ASCII encoding form. The reading method is similar BURST data reading: When reading, send 0x6A00~0x7000, and receive data. The output register content is offset by 2 cycles from the read instruction sending.

After concatenating 4 16-bit ID data into ASICII code, the complete ID of the product can be obtained. 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

6.3.4.4 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

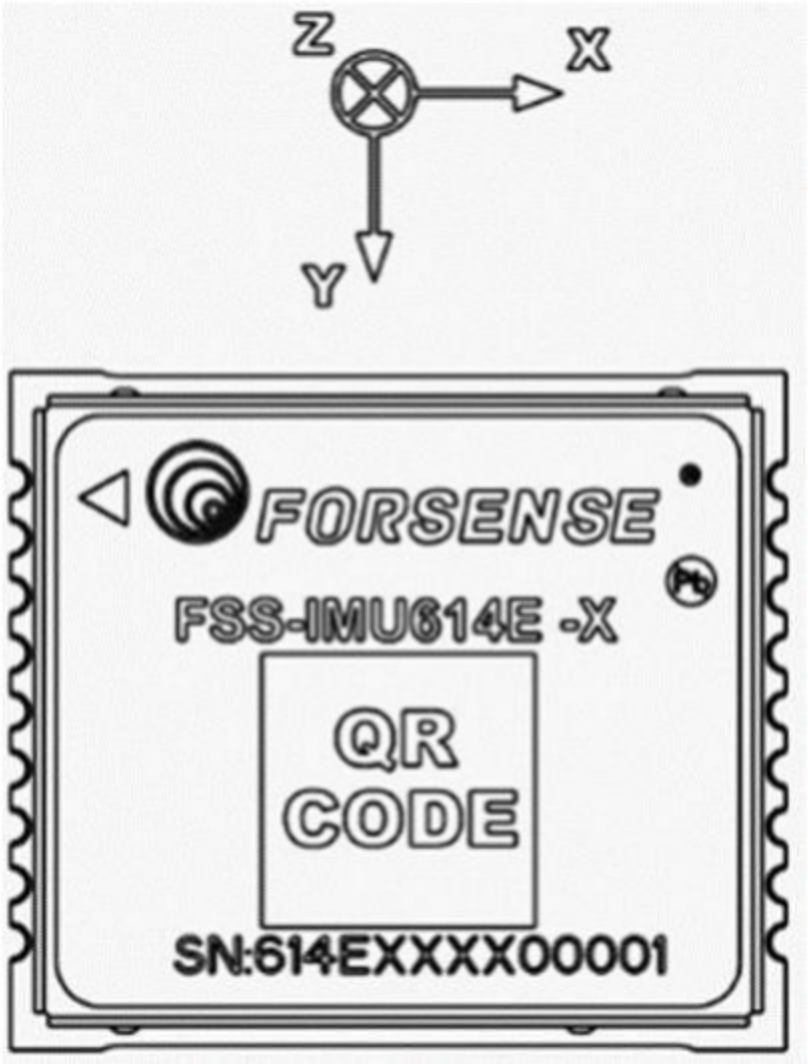
Address	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8	Read/Write
0x7F									RW
Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Read/write
0x7E	WINDOW_ID								RW

Table 38 SPI register WIN_CTRL.WINDOW_ID encoding

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

7 Definition of coordinate system

Figure 19 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: Course Angle Yaw range: 0° ~360°
Rotation around the X axis: Roll Angle Roll range: -180°~ 180°
Rotation around the Y-axis direction: Pitch

Angle Pitch range: -90°~90° Roll, pitch, heading

Angle diagram is as follows:

FIG. 20 Schematic diagram of roll, pitch and heading Angle

8. 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

```
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, 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,
```

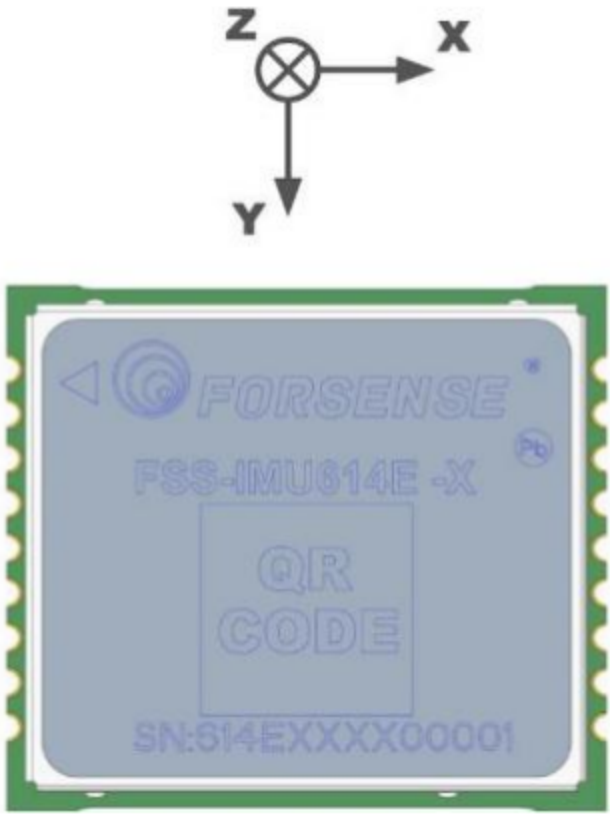
```
0xd80d2bda, 0xaf0a1b4c, 0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55,
0x316e8eef, 0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236,
0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe, 0xb2bd0b28,
0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31, 0x2cd99e8b, 0x5bdeae1d,
0x9b64c2b0, 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;
}
```

9 Use examples

9.1 Device Installation

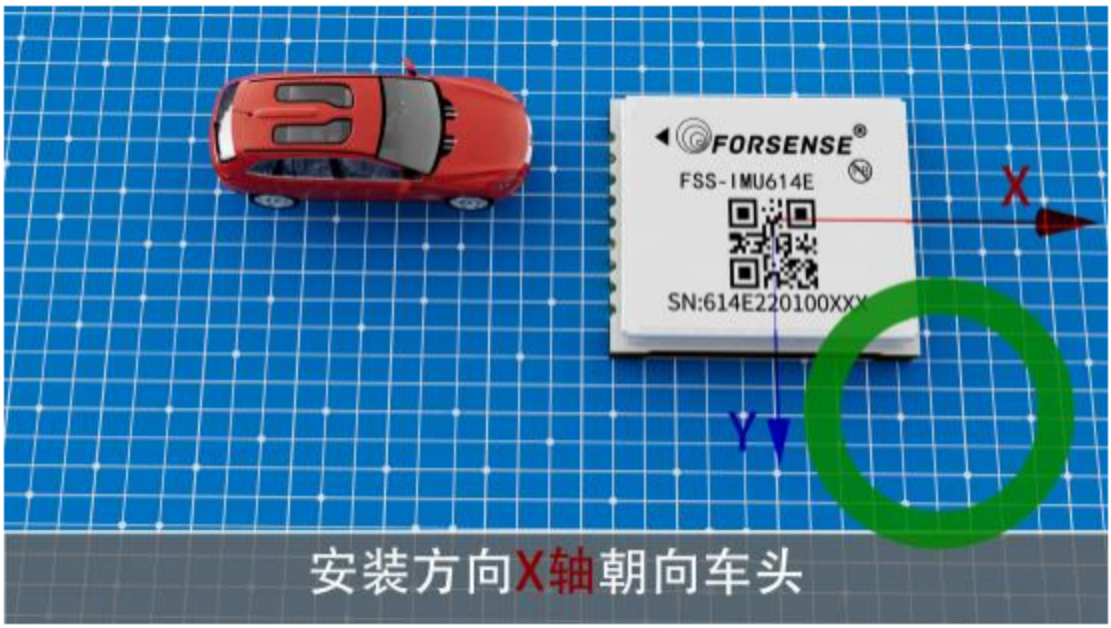
1. The module should be firmly fixed on a rigid plane and avoid being installed in a position with large vibration. 2. The module should be installed in the same direction as the front.

Figure 21 Schematic diagram of installing the module



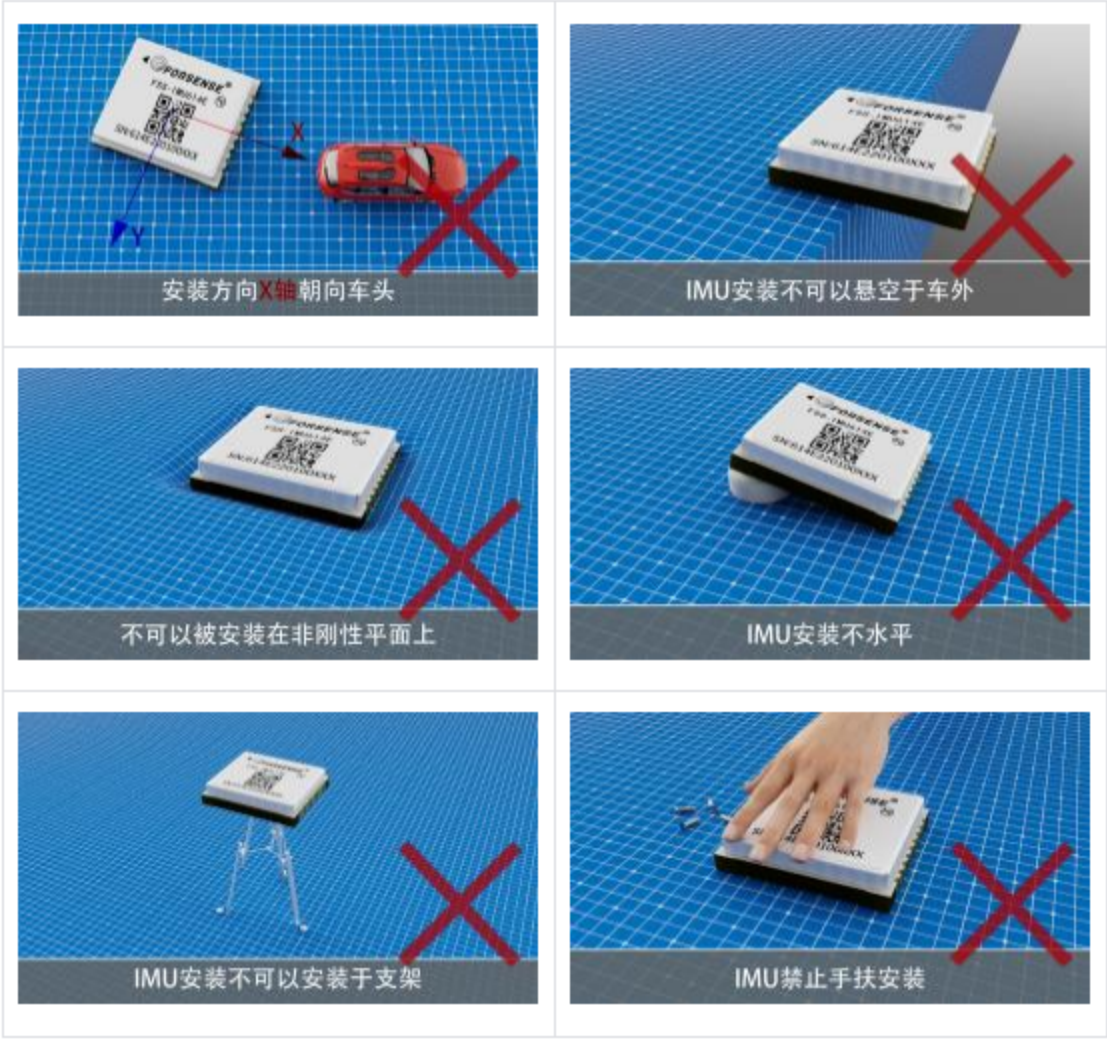
The correct installation diagram follows the X-axis towards the front of the car

Figure 22 Diagram of correct installation



The following installation methods are all incorrect installation

Figure 23 Schematic diagram of incorrect installation



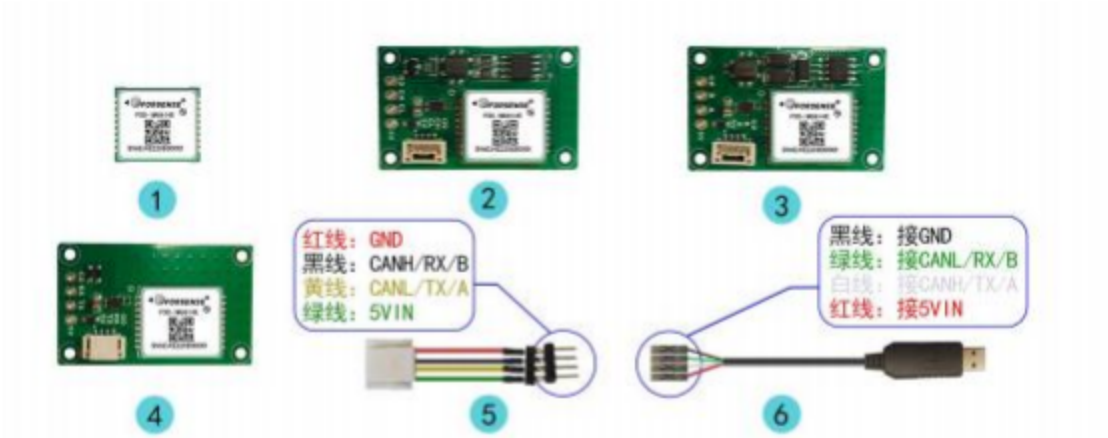
3. Precautions for IMU installation

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 24 Schematic diagram of prohibited items.


FORSENSE
FSS-IMU614E
SN:614E220100XXX
GND
IMU 周围禁止打胶或其他流动液体

9.2 Example for Connecting to the Host

Figure 25 Schematic diagram of connecting the module to the upper computer



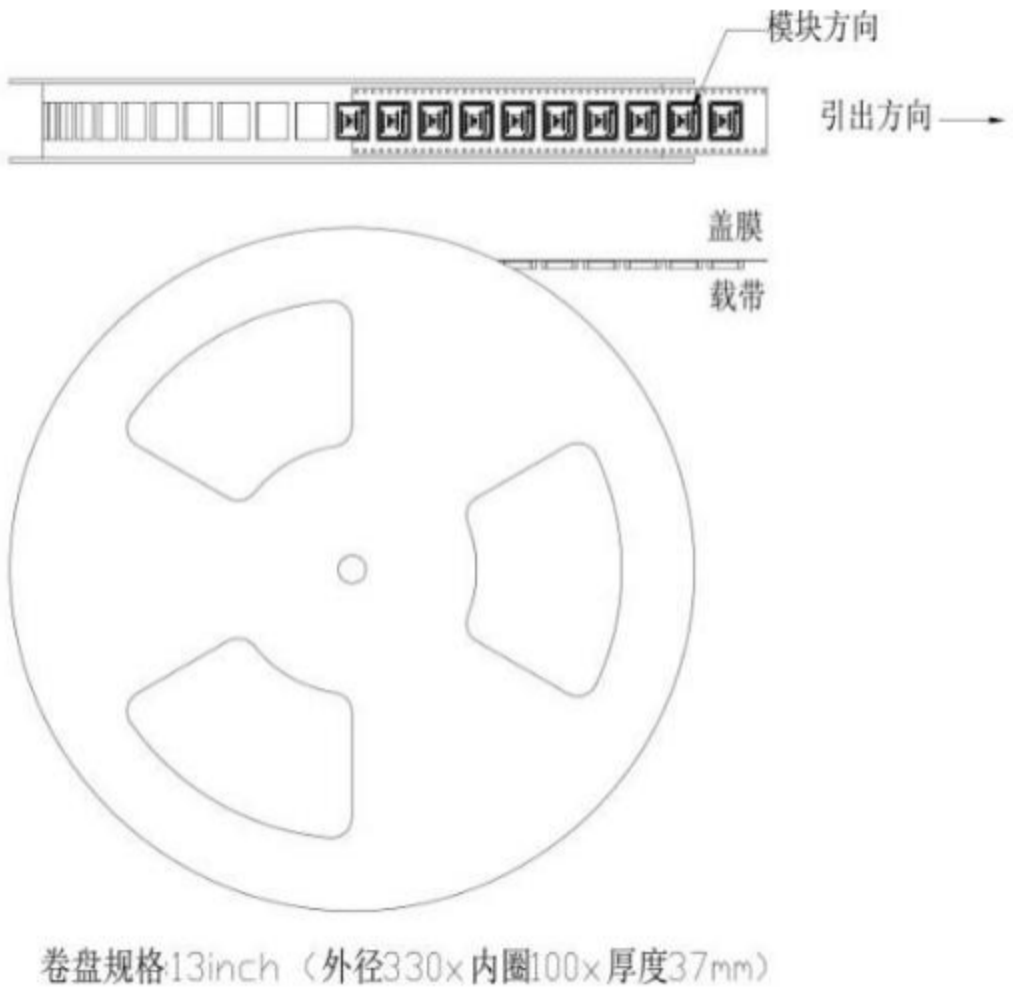
	名称	数量
1	IMU614E系列模组	1个
	附件名称	数量
2	贴片CAN版本测试底板	1个
3	贴片485版本测试底板	1个
4	贴片TTL版本测试底板	1个
5	4-PIN 接头	1个
6	TTL串口线	1个

Step 10: Packaging

The IMU614E-S module is packaged in a tape seal. Meet efficient production.

10.1 Roll and tape packaging

Figure 26 Schematic diagram of reel tape packaging



10.2 Tape Carrier

Figure 27 shows the position and orientation of the IMU614E-S on the load belt. Figure 27 IMU614E-S on the load belt.

11. Select accessories

IMU614E-X Test baseplate
(Old baseplate)

IMU614E-X Test baseplate
(New baseplate)

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

12 Update your records

Version	Dates	Status/Comments
Version 1.0	2024.08.21	First Edition