IMU614E-U_Product Sheet

Features

Tactical-grade MEMS Gyroscope

- Bias Instability: 5.5°/hr
- Angle Random Walk: 0.25°/√hr

Tactical-grade MEMS Accelerometer

- Bias Instability: 10μg
- Velocity Random Walk: 0.03m/s /√hr

Independent Rotary Table Calibration

- Independent calibration for every module includes: sensitivity, bias instability, and misalignment
- Temperature Range: -40℃ to 85℃

High-intensity Tolerance

- Ultra Shock Resistance: 2000g（0.5ms, half-sine shock pulse, 3-axis）
- Superb Vibration Resistance: 10g（10~2KHz, 3-axis）
- Stable Operating Temperature Range: -40℃ ~ 85℃
- 100% Magnetic Shielding

Real-time and Flexible Digital Interface with a Small Size

- Configurable output sampling rate up to 1kHz
- Serial ports, I2C and SPI supported
- 14.7*17*3.2mm, 1.6g

Description

IMU614E-U is a MEMS inertial measurement unit (IMU) module with 6 degrees of freedom (DOF) developed by Forsense (Shanghai) Technology Co., Ltd. It features three-axis gyroscopes and three-axis accelerometers.

High precision and resolution combined to help capture subtle vibration and tilt. All IMU modules are calibrated independently on a rotary table and adjusted precisely over an ultra-wide temperature range in a temperature chamber before leaving the factory, so that they can deliver stable and consistent performance in most extreme conditions.

Applications

- UAVs
- Flight controllers

Apart from standard performance and output parameters, Forsense also provides **customized** services, including software development and LOGO design, to better your products!

CONTENT

1 Performance Parameters

1.1 Gyroscope Key Metrics

Table 1 Gyroscope Key Specifications

Parameter	Test Conditions/Remarks	Min.	Typical	Maximum	Unit
Measurement Range			±2000		°/s
Bias Instability[1]	@25℃, ALLAN Variance, 1σ		5.5		°/hr
Bias Stability	GJB, 10s smoothing		20		°/hr
Bias Repeatability	GJB		150		°/h
Resolution			0.0610		°/s
Non-orthogonal between axes			0.02		deg
Internal Low-pass Cutoff Frequency	Adjustable Software		50		Hz
ODR			1000		Hz
Measure Delay			5.5		ms
Offset Error over Temperature[2]	-40℃ ~ 85℃, ≤1℃/min @1σ		0.12		°/s
Random Walk[1]	@25℃, ALLAN Variance, 1σ		0.25		°/√hr
Scale Coefficient Error	@25℃, 1σ		1.5		‰
Scale Factor Nonlinear			100		ppm

Note 1: IEEE standard values acquired from Allan Variance analysis in a static environment (25°C).

Note 2: 1σ variation of full-temperature bias at a heating rate of 1°C/min.

1.2 Accelerometer Key Metrics

Table 2 Accelerometer Key Metrics

Parameter	Test Conditions/Remarks	Min.	Typical	Maximum	Unit
Measurement Range			±32		g
Bias Instability[1]	@25°C, ALLAN Variance, 1σ		XY: 10 Z: 30		μg
Bias Stability	GJB, 10s smoothing		XY: 25 Z: 75		μg
Bias Repeatability	GJB		0.25		mg
Resolution			0.9766		mg
Misalignment between axes			0.02		deg
Internal Low-pass Cutoff Frequency	Adjustable Software		50		Hz
ODR			1000		Hz
Measure Delay			5.5		ms
Offset Error over Temperature[2]	-40°C ~ 85°C, ≤1°C/min @1σ		1.5		mg
Random Walk[1]	@25°C, ALLAN Variance, 1σ		0.03		m/s/√hr
Scale Coefficient Error	@25°C, 1σ		1.5		‰
Scale Factor Nonlinear			100		ppm

Note 1: IEEE standard values acquired from Allan Variance analysis in a static environment (25°C).

Note 2: 1σ variation of full-temperature bias at a heating rate of 1°C/min.

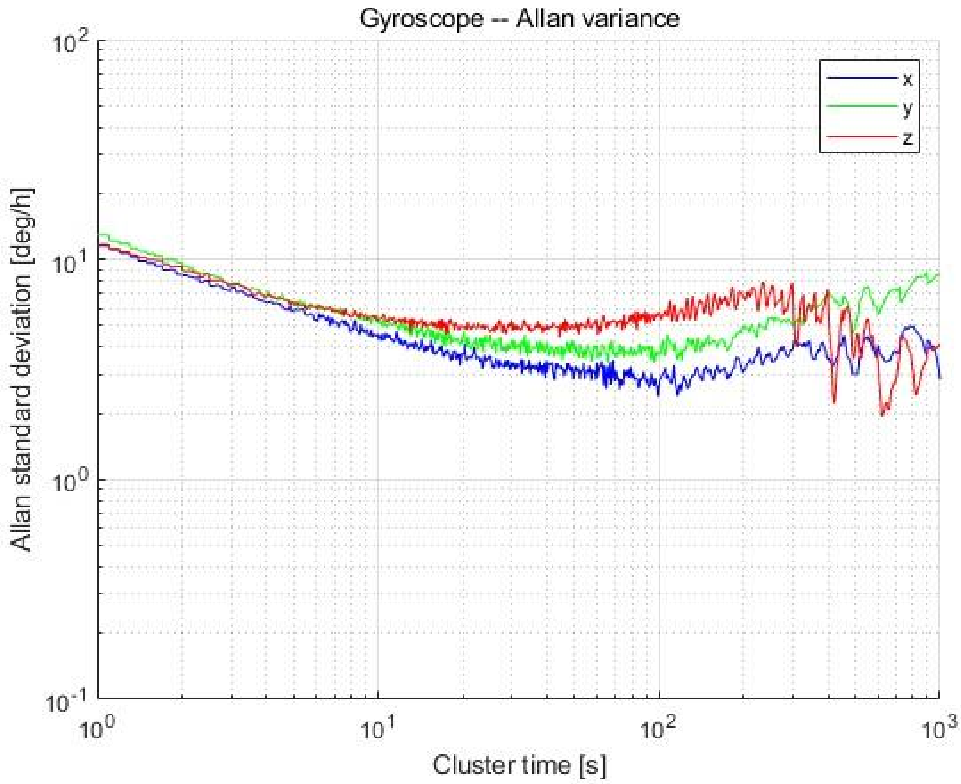


Fig. 1 Gyroscope - Typical Allan Variance Curve

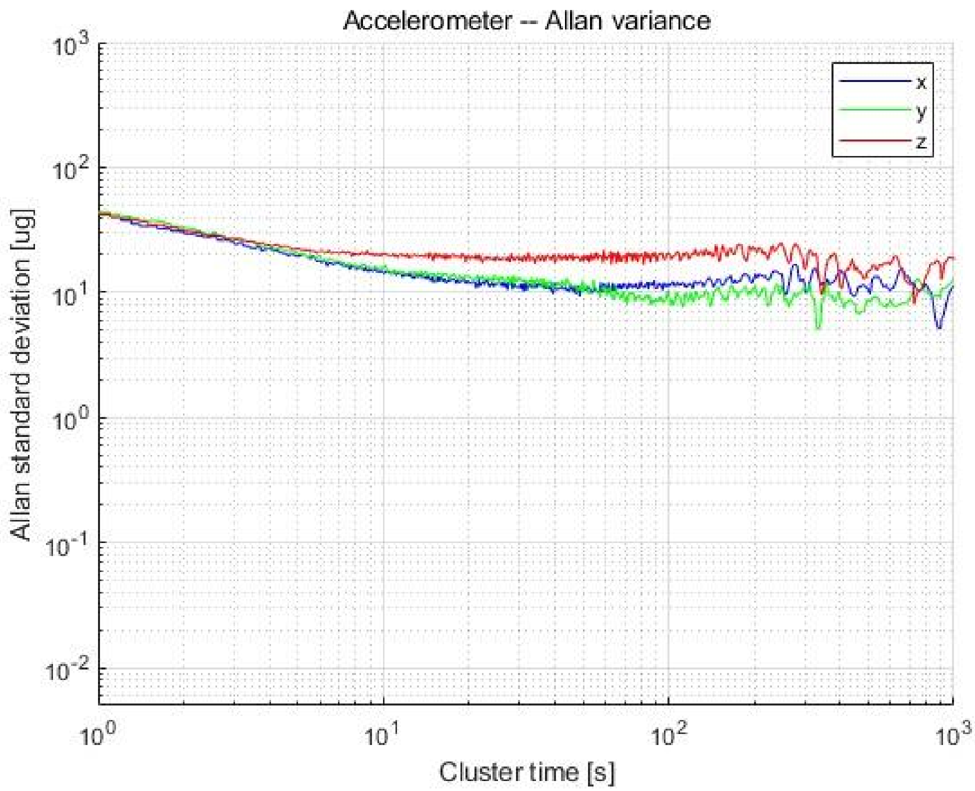
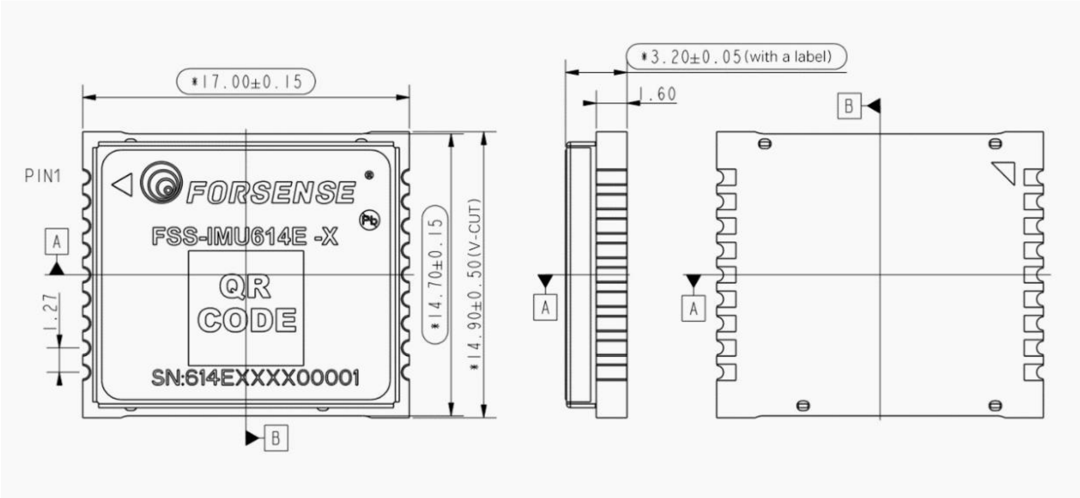


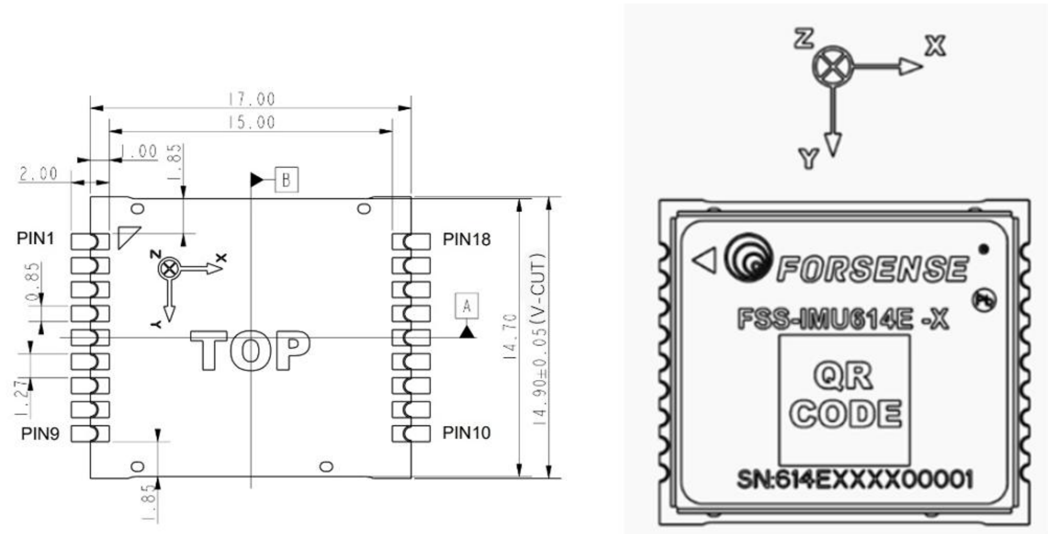
Fig. 2 Accelerometer - Typical Allan Variance Curve

2 External Structure



External Structure

Fig. 3 Structure and Recommended Pad Size (unit:mm)



Recommended size for bonding pad

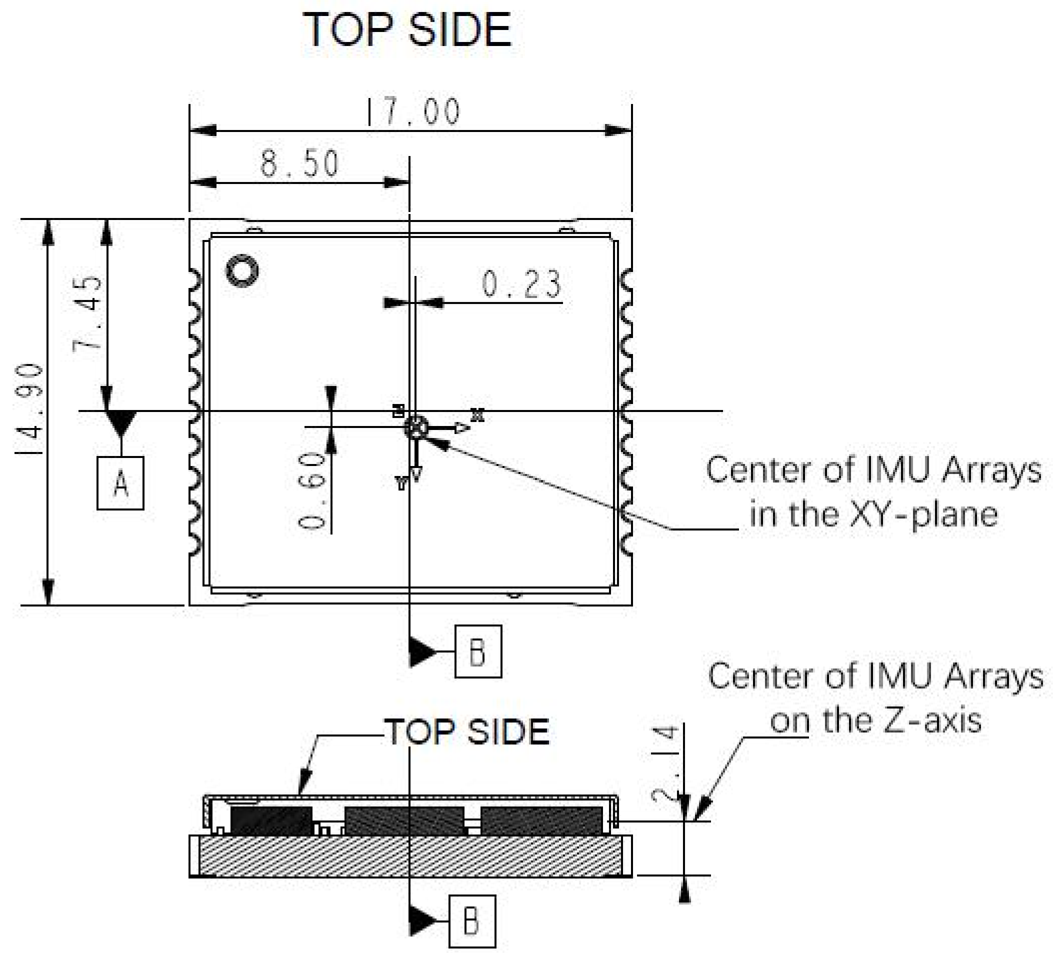


Fig. 4 IMU Array Center (unit: mm)

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

Parameter	Symbol	Range	Unit
Supply Voltage	VCC	-0.3 to 4.0	V
Ground	GND	-	-
Input Pin Voltage	Vin	-0.3 to VCC+0.2	V
Operating Temperature	Tot	-40 to 85	℃
Storage Temperature	Tstg	-40 to 85	℃

3.2 Operating Conditions

Table 4 Operating Conditions

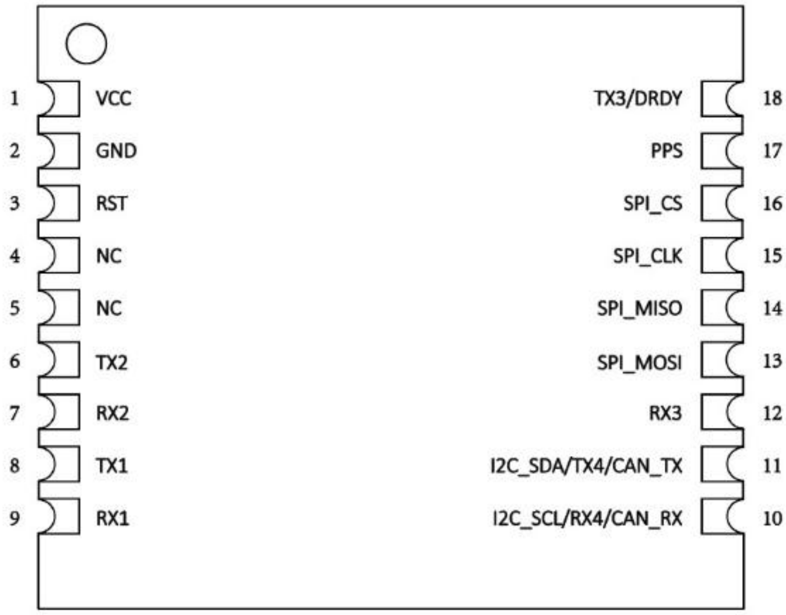
Parameter	Symbol	Minimum	Typical	Maximum	Unit
Supply Voltage	VCC	3.2	3.3	3.4	V
VCC Maximum Ripple	Vrpp		±40		mV
Power Consumption	P		0.13		W
Operating Temperature	T	-40		85	℃
Storage Temperature	T	-40		85	℃

3.3 IO Threshold Characteristics

Table 5 IO Threshold Characteristics

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Input Pin Low Level	Vin_low	0		VCC*0.2	V
Input Pin High Level	Vin_high	VCC*0.7		VCC+0.2	V
Output Pin Low Level	Vout_low	0		0.45	V
Output Pin High Level	Vout_high	VCC-0.45		VCC	V

4 Pin Definitions



IMU614E-X Pin Layout (Top View)

Fig. 5 Pin Diagram

Table 6 Pin Definitions

<table>
<tr><th>Pin No.</th><th>Pin Name</th><th colspan="3">Pin Description</th></tr>
<tr><td>1</td><td>VCC</td><td colspan="3">Power Input, +3.3V, 40mA, with ripple not exceeding ±40mV</td></tr>
<tr><td>2</td><td>GND</td><td colspan="3">Ground</td></tr>
<tr><td>3</td><td>RST[1]</td><td colspan="3">External hardware reset input, internal pull-up (for SPI mode)</td></tr>
<tr><td>4</td><td>NC</td><td colspan="3">No connection</td></tr>
<tr><td>5</td><td>NC</td><td colspan="3">No connection</td></tr>
<tr><td>6</td><td>TX2</td><td colspan="3">Receive asynchronous data output</td></tr>
<tr><td>7</td><td>RX2</td><td colspan="3">Receive asynchronous data input</td></tr>
<tr><td>8</td><td>TX1</td><td colspan="3">Receive asynchronous data output (Data communication interface (LVTTL))</td></tr>
<tr><td>9</td><td>RX1</td><td colspan="3">Receive asynchronous data input (Data communication interface (LVTTL))</td></tr>
<tr><td rowspan="4">10</td><td rowspan="4">CAN RX / RX4 / I2C_SCL</td><td>Mode</td><td>Function</td><td>Description</td></tr>
<tr><td>1</td><td>CAN_RX</td><td>CAN Receive Pin
Read data from bus and send them to CAN controller</td></tr>
<tr><td>2</td><td>RX4</td><td>Receive asynchronous data input</td></tr>
<tr><td>3</td><td>I2C_SCL</td><td>I2C Serial Clock</td></tr>
</table>

		Mod e	Functio n	Description
11	CAN TX / TX4 / I2C_SDA	1	CAN_T X	CAN Transmit Pin CAN TX pin: read data from CAN controller and send them to bus driver
		2	TX4	Receive asynchronous data output
		3	I2C_SD A	I2C Serial Data
12	RX3	Receive 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 Chip Select		
17	PPS	Signal to trigger external synchronized sampling; (access to the pulse per second pin of RTK)		
18	TX3/DRDY	Receive asynchronous data output/ available for Data Ready		

Note 1: IMU hardware needs to be reset by triggering /RST to reset the IMU hardware.

For more information about IMU hardware design, please refer to the document . IMU614E-XX Hardware Design Manual

5 Recommended Welding Furnace Temperature Profile

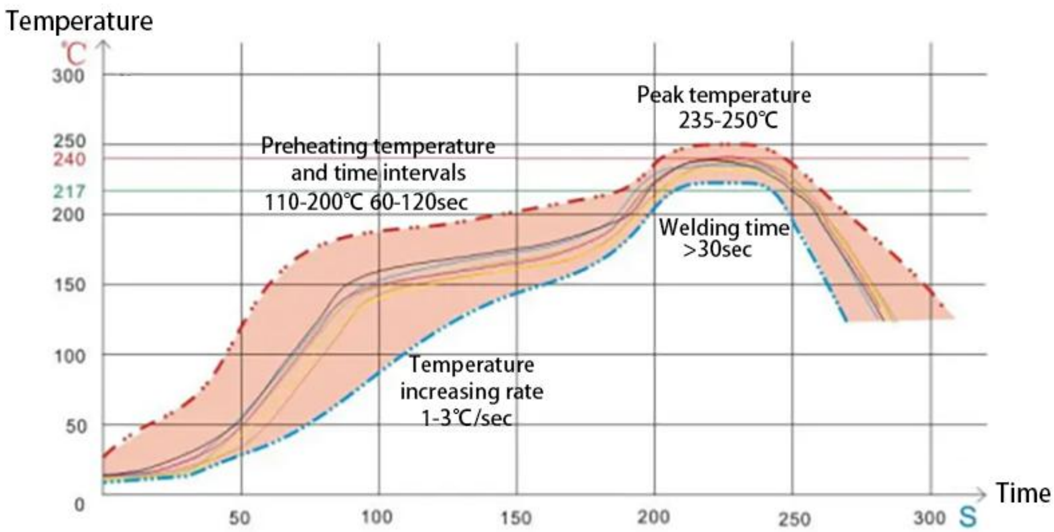


Fig. 6 Welding Furnace Temperature Profile

Table 7 Temperature Setting Modes

Parameter	Minimum	Maximum	Unit
Maximum Temperature ramp-up rate (target = 0.8) (calculated every 60 seconds)	1	3	°/s
Maximum Temperature ramp-down rate (calculated every 60 seconds)	-3	-1	°/s
Preheating temperature and time intervals	60	120	s
Reflow time (period over 217°C)	40	70	s
Maximum temperature	235	250	°C
Maximum number of reflow		1	Times

For more information about SMT modules, please refer to the document .Forsense - LCC Module_SMT Application Guide

Notes:

1. For modules, it is recommended to use reflux welding equipment with eight or higher temperature zones;

2. The module is a high-precision sensor sensitive to any deformation;

• If the thickness of the PCB board is less than 1.0 mm, it is recommended to use reflow fixtures to prevent the board from getting deformed under high temperature, thereby ensuring the coplanarity of pins.

- It is recommended that customers use high TG value boards as PCB main boards to avoid deformation during high temperature reflow, thus reducing the possibility of warping, extrusion, empty soldering, and solder bridging.

3. Due to the sensitive devices inside the module, the maximum temperature of the reflux soldering machine must not exceed 260°C (referring to the the top surface temperature of the package);

4. It is recommended to use lead-free solder paste, including the recommended product Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5;

5. Given sensitive devices in the module, the second reflux should be avoided to ensure proper performance of the module;

6. Cooling;

- Controlled cooling ramp rate can help reduce negative soldering effects (e.g. more brittle solder joints) and mechanical stresses within the product. Controlled cooling contributes to bright soldered surfaces with fine crystalline particles and low contact angles, avoiding the warping of the shielding cap caused by rapid cooling changes.

7. Exterior inspection:

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

8. **When using electric soldering, the ironing temperature shall be controlled at 260 °C to 290 °C, the single welding time shall not exceed 3s, and the anti-static treatment shall be done.**

6 ESD Protection

Fig. 7 ESD Protection

Static electricity may cause intermittent or permanent circuit damage, which is very harmful to electronic products. Most of them are identified as ESD damage.

Therefore, the electrostatic protection of modules is particularly important. The production and transportation process needs to be strictly subject to the following conditions:

- It is prohibited to touch the module, especially the pin position, with bare hands;
- SMT patch machines, workstations, soldering irons and other equipment need to be grounded;
- Operators wear human anti-static bracelets with grounding wires (cordless static bracelets are not allowed and anti-static gloves are recommended);
- Packaging and PCBs must be made of qualified anti-static materials.

7 Communication Protocols

7.1 Serial Communication Protocols

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

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

Serial communication has two modes: Stream Mode and Command Mode.IMU enters a specific mode based on corresponding parameters after the IMU has been powered on and initialized.

Stream Mode: Output AHRS data periodically at a fixed frequency;

Command Mode: In this mode, the periodic output will stop, and users communicate with the IMU by sending commands, which can be used to obtain sensor data, status, parameters and other information via the GET command and to configure the parameters of the IMU.

7.1.1 Serial Port Parameters

Table 8 Serial Port Parameters

Transmission rate range	115200bps ~ 1.5Mbps
Default transmission rate	115200bps
Start Bit	1 bit
Data Bit	8 bits
Stop Bit	1 bit
Parity Check	/

7.1.2 Packet Format

The IMU output and user input packets consist of the following:

Table 9 IMU Output and User Input Data Structure

Offset	Data type	Name	Description
0	uint8	Frame header 1	IMU output frame header: 0xAA, 0x55 User input frame header: 0x55, 0xAA
1	uint8	Frame header 2	
2	uint16	ID Low Byte	Low byte of serial communication frame ID
3		ID High Byte	High byte of serial communication frame ID
4	uint16	Low Byte of Data Length	Low byte of serial communication frame ID The length represents the number of bytes occupied by the payload, i.e. n
5		High Byte of Data Length	High byte of serial communication frame ID

			The length represents the number of bytes occupied by the payload, i.e. n
6	uint8	Payload (n bytes)	Data Load
6+n	Uint32	CRC_CEHCK (32-bit data low bytes)	CRC verification
7+n		CRC_CEHCK (32-bit data low middle bytes)	
8+n		CRC_CEHCK (32-bit data high middle bytes)	
9+n		RC_CEHCK (32-bit data high bytes)	

Note 1: The data is transmitted in little-endian format, with low byte first and then high byte.

Note 2: The initial value of crc32 is 1 and the CRC calculation does not include all the data of the frame itself. Please refer to CRC Look-up Table Calculations at the end of the document.

7.1.3 Stream Frame - AHRS Data

Table 10 Serial AHRS Data Format

	Frame header	Frame header	ID	length	payload	Frame trailer
Data type	uint8	uint8	uint16	uint16	A1	uint32
Encode	0xAA	0x55	0x0002	0x002C		crc32

Note 1: Maximum output update rate is below 200Hz@115200bps.

Table 11 Serial A1 Load Data Format

offset	Name	Data type	Unit	Description
0	timer	uint32	μs	Time scale
4	pitch	float	°	Pitch angle
8	roll	float	°	Roll angle
12	yaw	float	°	Yaw angle
16	ax	float	g	X-axis acceleration
20	ay	float	g	Y-axis acceleration
24	az	float	g	Z-axis acceleration
28	gx	float	°/s	X-axis angular velocity
32	gy	float	°/s	Y-axis angular velocity

36	gz	float	°/s	Z-axis angular velocity
40	temp	float	℃	IMU Chip Temperature

Example of AHRS data stream acquired:

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

The analysis is as follows:

Table 12 AHRS data stream acquired by Serial A1

Description	Raw value	Parsed value	Description	Raw value	Parsed value
ID	0200	02	Y-axis acceleration	BC74133C	0.009g
Length	2C00	44	Z-axis acceleration	60E580BF	-1.007g
Time scale	6D891605	85363053	X-axis angular velocity	EC5138BD	-0.045°/s
Pitch angle	8FC26540	3.59°	Y-axis angular velocity	0AD7A3BB	-0.005°/s
Roll angle	14AE07BF	-0.53°	Z-axis angular velocity	CDCCCCBC	-0.025°/s
Yaw angle	5C0FB243	356.12°	IMU Chip Temperature	D7A3EE41	29.83℃
X-axis acceleration	2506813D	0.063g	CRC32 verification	0CBF8480	2156183308

7.1.4 Command Mode GET Output - System Status

Table 13 Serial System Status Data Format

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

Note 1: The frame length may vary across different IMU models, all representing the length of S1, which required confirmation based on the specific IMU model.

Table 14 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 number
18	sn2	uint32	Third SN number
22	Board_version	uint32	Base plate version number
26	Rev[16]	Uint8	All subsequent bytes are reserved

Note 1: Different IMU models have different subsequent reserved bytes which need to be further confirmed. IMU614E has 16 bytes.

Example: Acquiring system status

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

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

The response data are analyzed to get the software version number 211231(1F 39 03 00) and hardware version number 94053(65 6F 01 00).

7.1.5 Command Mode GET Output - Reading Parameters

Table 15 Data Format for Serial Port Parameter Input

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

Table 16 Data Format for Serial Port Parameter Output

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

Note 1: The IMU will turn the data stream off when reading the parameters, thus it is necessary to turn it back on when the setup is completed.

Table 17 Serial P1 Load Data Format

offset	Name	Data type	Description
0	Param1	float	Parameters acquired (input

			data can be ignored)
4	Param2	float	Reserved, 0 (Default)
8	Param3	uint32	Parameter index settings
12	Param4	uint32	Reserved, 0 (Default)
16	Param5	Int32	Reserved, 0 (Default)
20	Param6	Int32	Reserved, 0 (Default)

Table 18 Serial P1 Load Parameter Index

Param 3	Param1	Unit
3	Serial output baud rates, including 115200、230400、460800、921600、1500000	bps
4	Coordinate system orientation (see table 25 for coordinate system orientation correspondence)	
8	X-axis gyro bias calibration result, GYRO_X_OFF	°/s
9	Y-axis gyro bias calibration result, GYRO_Y_OFF	°/s
10	Z-axis gyro bias calibration result, GYRO_Z_OFF	°/s
21	AHRS output data rate, 100Hz (Default)	Hz
31	Internal filter configuration as defined in SPI's FILTER_CTRL comparison chart	

Example: Acquiring AHRS output data rate

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

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

The response data are analyzed to get the output data rate 50hz (00 00 48 42).

7.1.6 Command Mode SET Instructions

Table 19 Serial Input Command Format

	Frame header	Frame header	ID	length	payload	Frame trailer
Data type	uint8	uint8	uint16	uint16	R1	uint32
Encode	0x55	0xAA	CMD	0x0018		crc32

Note 1: See R1 Load Parameter Index Table for the detailed relation between CMD and R1.

Table 20 Serial R1 Load Data Format

offset	Name	Data type	Description
0	Param1	float	Parameters settings
4	Param2	float	Reserved, 0 (Default)
8	Param3	uint32	Parameter index settings
12	Param4	uint32	Reserved, 0 (Default)
16	Param5	Int32	Reserved, 0 (Default)
20	Param6	Int32	Reserved, 0 (Default)

Table 21 Serial R1 Load Parameter Index

CMD	Param1	Param3	Description
1	0	0	Triggered to acquire system status data once
2	0	0	Triggered to acquire AHRS data once
3	<mode>	0	Set the output mode: Mode=1, outputting AHRS data in a streaming format. Mode=100, disabling data streaming and initiating COMMAND mode.
5	0	0	Save current parameters to FLASH
6	0	<value>	Read parameters, and <value> is the parameter index to be read, i.e. P1.index. For details, please refer to Serial Port Parameters Output in Response to indexes. Examples: set <value>=21 to read AHRS output data rate(ODR), set <value>=3 to read the serial port baud rate, set <value>=31 to read the internal filter, set <value>=4 to read the direction of the coordinate system.
9	0	0	Software restart
14	<value>	3	Set the serial output baud rate (unit: bps), and the valid values of BPS are: 115200, 230400, 460800, 921600, 1500000 If <value> is the values other than those mentioned above, the default is 115200bps. Restart the software after setting the baud rate parameters. Setup process with uninterrupted power: set baud rate, save parameters to FLASH, and restart software.
14	<value>	21	Set the AHRS output data rate (unit: Hz), and the commonly used values are 1, 10, 50, 100, 200, 500, 1000. Recommended correlation between output data rate and serial port baud rate 1000Hz：921600bps 500Hz：460800bps 250Hz：460800bps 200Hz：460800bps 100Hz：115200bps
14	<value>	31	Internal filter configuration, the definition of which is the

			same as that of SPI accelerometer and gyroscope filter configuration. The default is 0xBB, i.e. 47Hz.
14	<value>	4	Set the IMU coordinate system orientation, the range of <value> is 101 to 124, see table 25 for the specific coordinate system orientation correspondence.

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

Note 2: Click "Command Generator" and then send corresponding commands.

If the AHRS output is turned on:

CMD ID is filled with 3, parameter 1 is filled with 1, and the generated hexadecimal array can be added to the serial assistant or program array which will be sent to IMU.

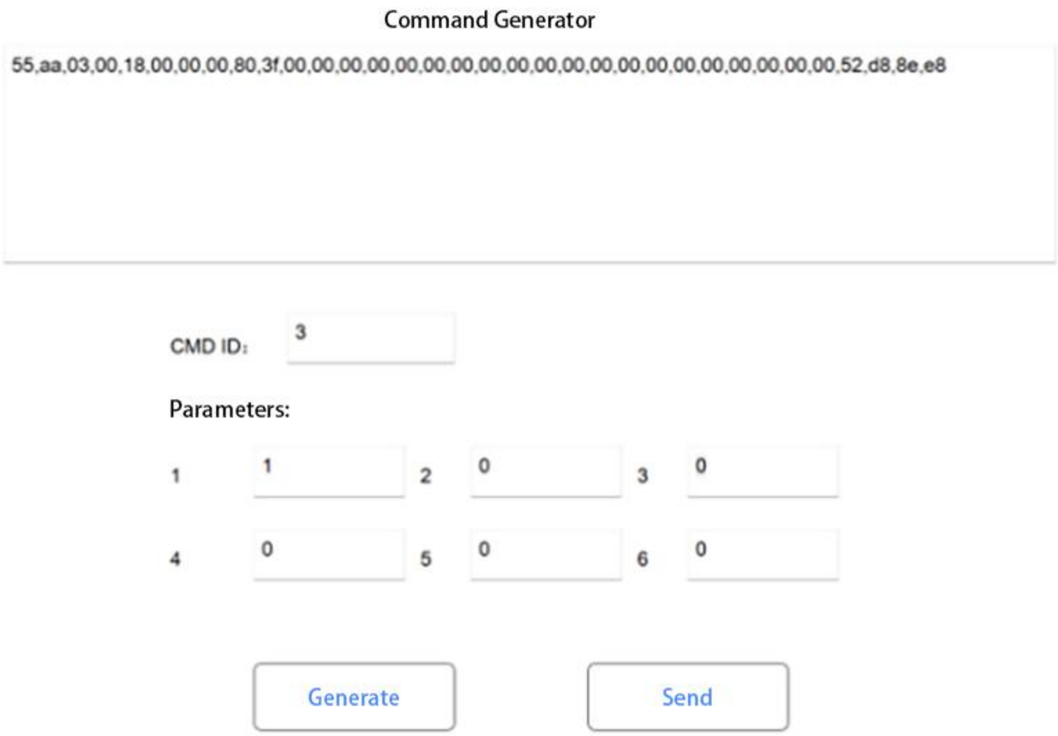


Fig. 8 Turn on AHRS Output

7.1.7 Command Mode Output - User Command Response

Table 22 Setting Response Data Format for Parameters Serial Port

	Frame header	Frame header	ID	length	ACK	Param3	Frame trailer
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32

Encode	0xAA	0x55	0x753D	0x0004	0x7534	Paramete r Index	crc32

Table 23 Reserving Response Data Format for Parameters Serial Port

	Frame header	Frame header	ID	length	ACK	result	Frame trailer
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Encode	0xAA	0x55	0x753D	0x0004	0x0005	0x01	crc32

Table 24 Serial Data Format in Response to User Commands

	Frame header	Frame header	ID	length	comman d	result	Frame trailer
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Encode	0xAA	0x55	0x0064	0x0004	Comman d ID	0x01	crc32

Example: Set the serial output baud rate 115200

Input data: 55,AA,0E,00,18,00,00,00,E1,47,00,00,00,00,03,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,0 0,56,2B,4D,93

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

Set periodic AHRS data with output frequency 100hz

Input data: 55 AA 0E 00 18 00 00 00 C8 42 00 00 00 00 15 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 current parameters to 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 C9 2F E6 32

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

Set the output mode to AHRS data stream

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

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

7.1.8 DRDY

The DRDY pin output serves two purposes:

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

2. to provide a signal to indicate the start of data frame transmission.

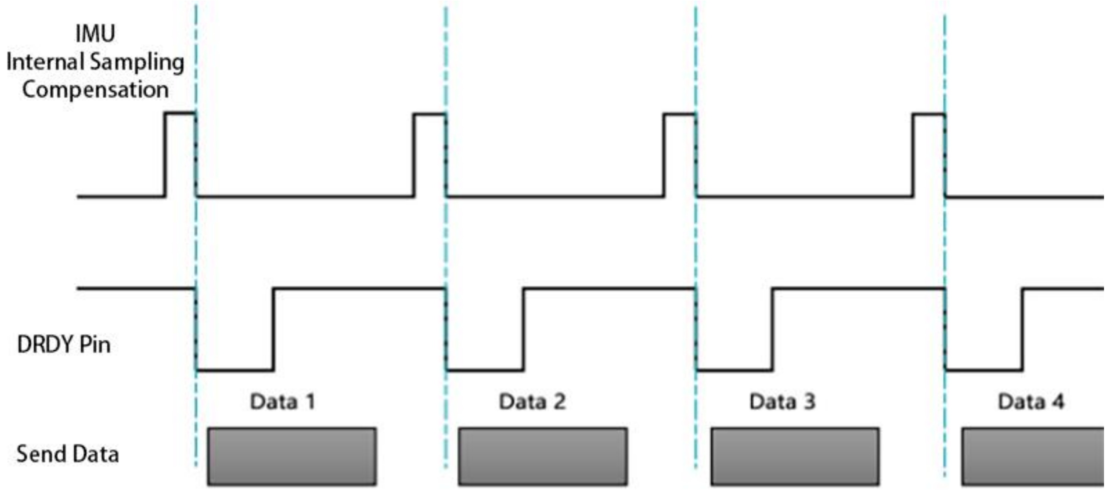


Fig. 9 Consistent Frequency between Internal Sampling and Serial Output

When the IMU internal sampling frequency (maximum ODR) equals the serial output frequency (current ODR), the DRDY pin will be pulled down immediately after the imu data sampling compensation is complete. At that time, the data frame will be sent from the serial port, and the DRDY pin will be pulled high again in the next cycle.

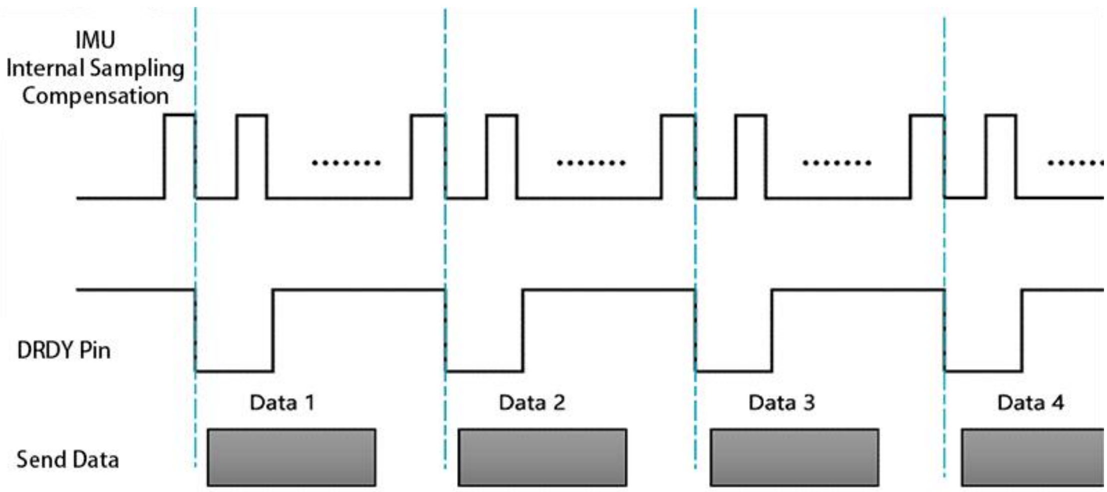


Fig. 10 Serial Output Frequency Less Than IMU Internal Sampling Frequency

When the serial output frequency is less than the IMU internal sampling frequency, the fractional frequency value (maximum ODR/current ODR) will determine whether the DRDY pin will be pulled down immediately after the IMU data sampling compensation is completed. After DRDY pin 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 cycle.

7.1.9 Coordinate System Setup

Set the firmware coordinate system and display the corresponding coordinate system in the Forsense PC software.

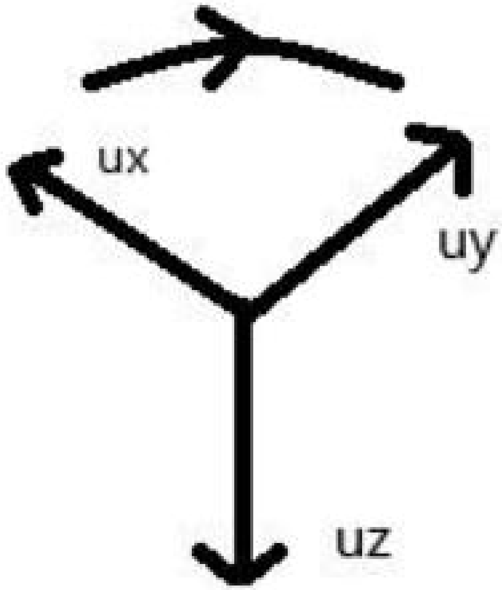


Fig. 11 Original Firmware Coordinate System

According to the rules in the above figure, the Z axis is also determined after the X and Y axes are determined. The Z-axis is perpendicular to XY-plane.

In total, there are 24 orientations for X, Y and Z axes, as shown in the table below:

Table 25 Coordinate System Orientation Correspondence

Orientation (value)	X-Axis	Y-Axis	Z-Axis	Description
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:

Fill CMD ID with 14, parameter 1 with 102, and parameter 3 with 4. The generated hexadecimal array can be added to the serial assistant or program array which will be sent to IMU.

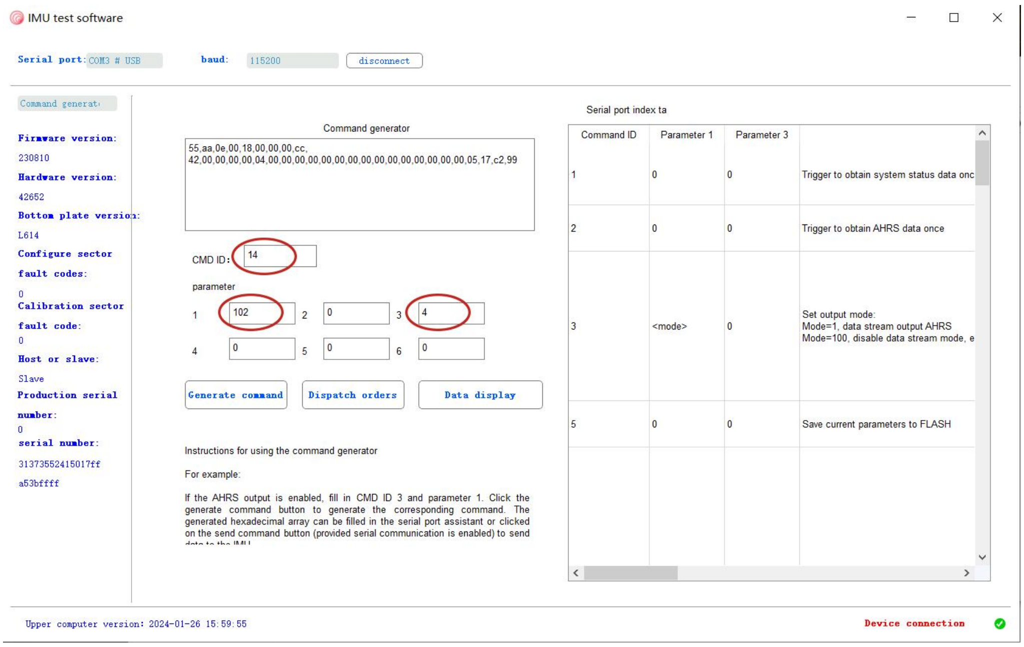


Fig. 12 Change the coordinate system to 102 orientation:

How to read the coordinate system orientation:

CMD ID is filled with 06, parameter 3 is filled with 4, and the generated hexadecimal array can be added to the serial assistant or program array which will be sent to IMU.

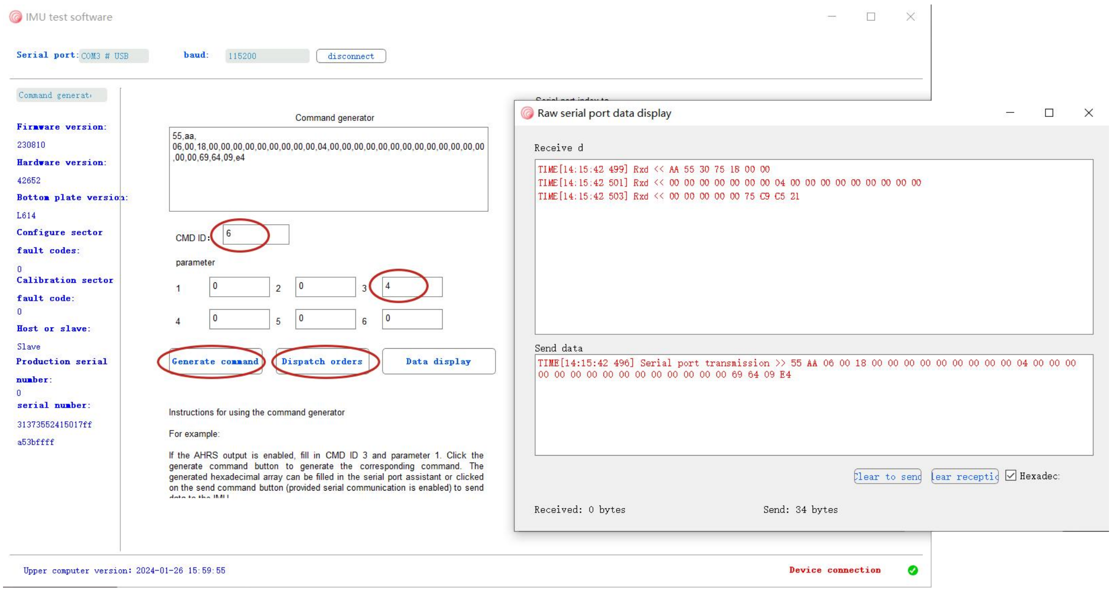


Fig. 13 Read the coordinate system orientation:

Example: Setting the coordinate system to 115 orientation.

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

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

Refer to table 22 and acquire the parameter index 04, then the setting is success.

Read the coordinate system:

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

Response data: AA 55 30 75 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 B2 2F 2D 4E

According to tables 16 and 17, parameter 1 is 115 (float) and parameter 3 is 04, which means the orientation of coordinate system is 115. Setting the coordinate system to 115 orientation.

7.1.10 Serial Connection FAQs

1) IMU receiver (RX) can not be connected to 2 host transmitters (TX)

The RX of the serial port can not be connected to two TX at the same time. When connecting to Forsense PC software is needed, please first disconnect its serial communication with the master, otherwise the PC software can only receive the data and cannot send commands to the IMU.

As shown in the figure below:

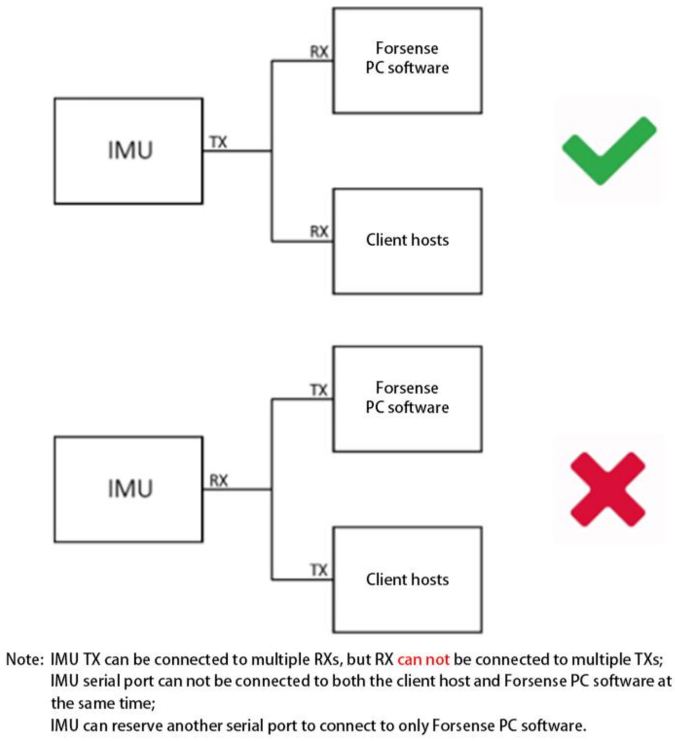


Fig. 14 Serial Connection Diagram

2) Unable to get the version number

Check whether the data is lost. It is recommended to use the FT232 chip serial cable. Data cables CH340 and PL2303 at high baud rate (>115200bps) will lead to data loss.

It is recommended that the serial cable be connected directly rather than in series. If interface RS422 is connected to the computer, it is recommended to directly use the RS422 to USB converter instead of using the RS422 to RS232 + RS232Z to USB converters in series.

3) The PC software curve display is stuck

If using FT232 data cable, open the Forsense PC software by selecting "Run as administrator" and configure the serial delay automatically.

Manually configure the serial delay in the device manager.

7.2 I2C Communication Protocols

Examples of how a STM32-based I2C host reads driver:

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

7.2.1 I2C Interface Parameters

Table 26 I2C Interface Parameters

I2C Rate	Conditions/Remarks
I2C Slave address (7 bits)	0x18

7.2.2 I2C Connection Methods

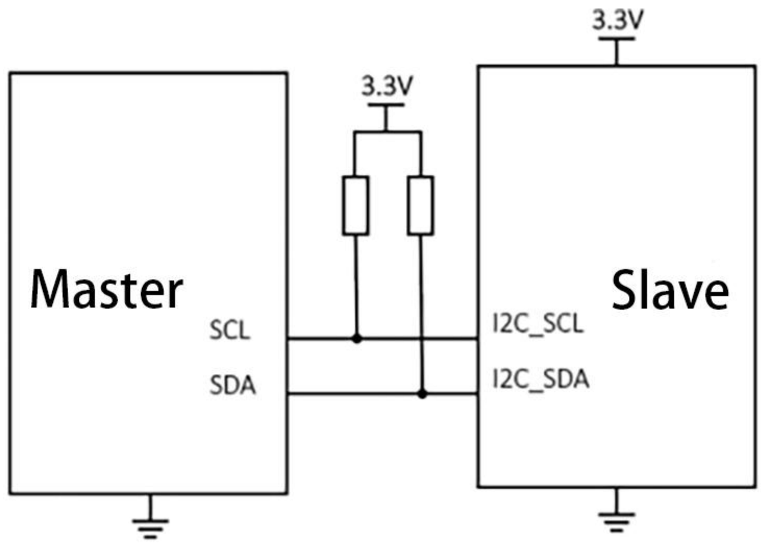


Fig. 15 I2C Connection Methods

Note: The pull-up resistor value is 4.7KΩ

7.2.3 I2C Register

Table 27 I2C Register List

Name	Address	Read/Write	Default Value	Description
BURST	0x12	R		Reading registers continuously
FILTER_CTRL	0x06	RW	0xBB	Filter selection
PROD_ID	0x6A	R		Product name

7.2.3.1 I2C BURST Register

This I2C protocol supports continuous reading of register address 0x12, and the slave automatically accumulates the address and outputs 48 bytes continuously in 8bit mode. The read process is as follows:

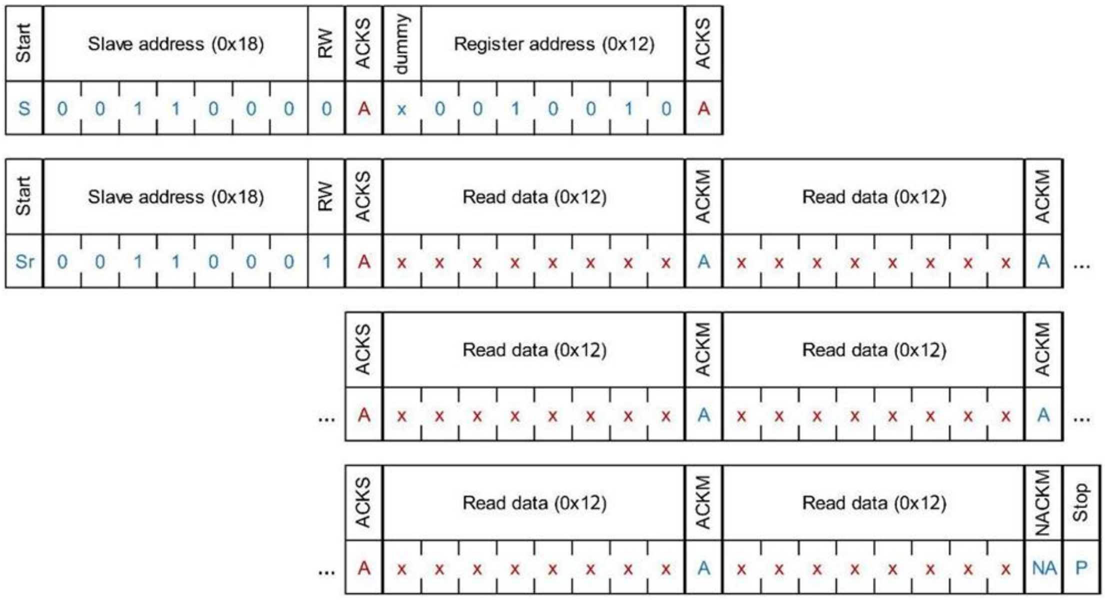


Fig. 16 I2C Continuous Reading Mode

The frame definition is as follows:

Table 28 I2C Continuous Data Format Reading

Transmit sequence	1	2	3
Data format	uint32_t	float	float
Transmit content	TIME	ACCL_X	ACCL_Y
Transmit sequence	4	5	6
Data format	float	float	float
Transmit content	ACCL_Z	GYRO_X	GYRO_Y
Transmit sequence	7	8	9
Data format	float	float	float
Transmit content	GYRO_Z	TEMP	ROLL
Transmit sequence	10	11	12
Data format	float	float	uint32
Transmit content	PITCH	YAW	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 °.

Note 2: The initial value of crc32 is 1 and the CRC calculation does not include all the data of the frame itself. Please refer to CRC Look-up Table Calculations at Appendix 1.

7.2.3.2 I2C FILTER_CTRL Register

FILTER_CTRL register address is 0x06, and the comparison table of filter configuration is the same as that of SPI accelerometer and gyroscope filter configuration. The register read process has the same read method as the I2C BURST, and the register write process is shown in the following figure.

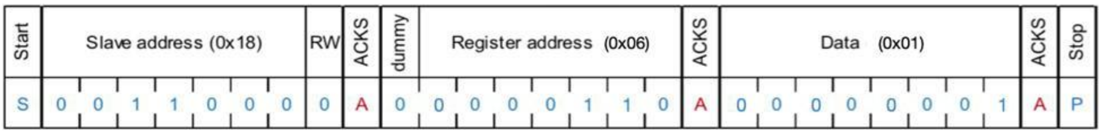


Fig. 17 I2C FILTER_CTRL Register Write Method

7.2.3.3 I2C ID Register

The ID register address is 0x6A and the data content is the character "IMU61B" encoded in ASCII, and the read process is the same as I2C BURST, as shown in the following table.

Table 29 I2C ID Register Read Mode

Transmit sequence	1	2	3	4
Transmit content	0x00	0x00	0x49	0x4D
Transmit sequence	5	6	7	8
Transmit content	0x55	0x36	0x31	0x*

Note 1: All data are in 8-bit width.

Note 2: 0x* is the product ID, 0x32 is the IMU612, 0x34 is the IMU614, 0x38 is the IMU618, 0x41 is the IMU6132A, and 0x42 is the IMU6132B.

7.3 SPI Communication Protocols

Examples of how a STM32-based SPI host reads driver:

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

7.3.1 SPI Interface Parameters

Table 30 SPI Interface Parameters

SPI master	This product acts as a slave
SPI rate	0.2~2MHz
SPI word length	16bit
Phase	Rising edge trigger (mode 3, CPHA=1)
Polarity	Idle high state (mode 3, CPOL=1)
Bit sequence	MSB-First

7.3.2 SPI Connection Diagram

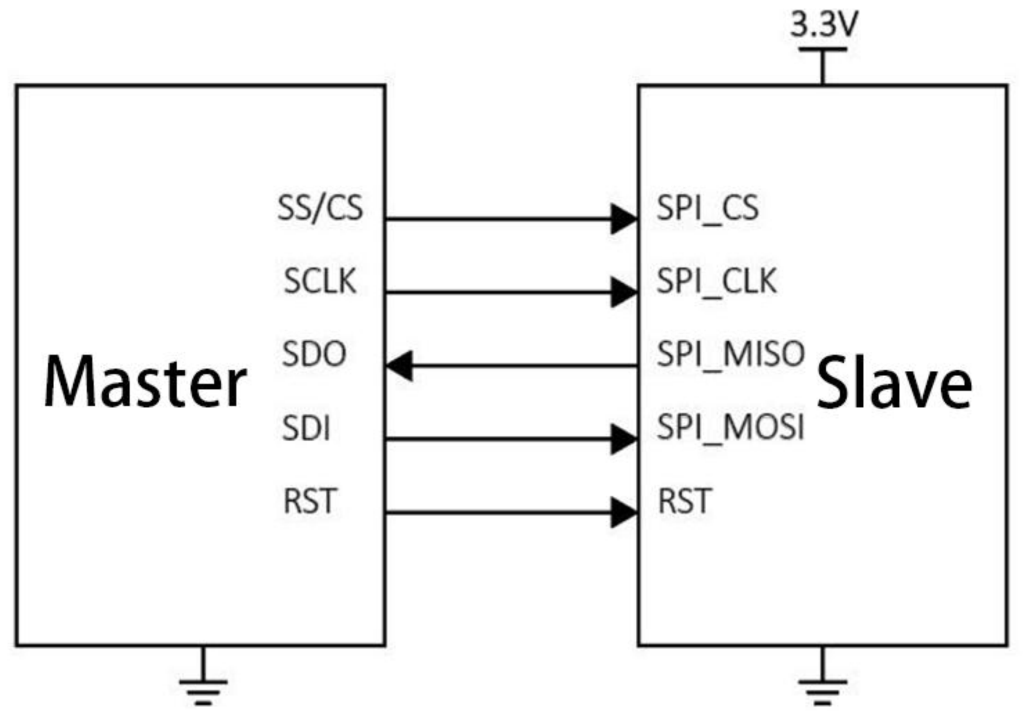


Fig. 18 SPI Connection Diagram

Note 1: Before the host initialization and data reading, reset the IMU and wait for 3s to make it enter normal operating mode.

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

7.3.3 SPI Communication Bit Sequence

The SPI interface supports full-duplex serial communication (simultaneous transmitting and receiving) using the bit sequence shown below.

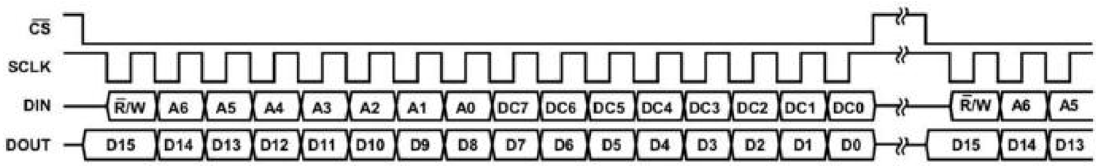


Fig. 19 SPI Communication Bit Sequence Diagram

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

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

indicates the register output data of the last two cycles, seeing the BURST reading example for details.

7.3.4 SPI Register

Table 31 SPI Register List

Name	Address	Read/ Write	Default Value	Window ID	Description
BURST	0x00	RW		0	Continuous reading
FILTER_CTRL	0x07,0x06	RW	0x00BB	1	Filter selection
PROD_ID1	0x6C	R	0x494d	1	ID No. 1
PROD_ID2	0x6E	R	0x5536	1	ID No. 2
PROD_ID3	0x70	R	0x3132	1	ID No. 3 (IMU612)
			0x3134	1	ID No. 3 (IMU614)
			0x3138	1	ID No. 3 (IMU618)
			0x3141	1	ID No. 3 (IMU6132A)
			0x3142	1	ID No. 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 high byte
XGYRO_LOW	0x14	R	\	0	Gyro X-axis low byte
YGYRO_HIGH	0x16	R	\	0	Gyro Y-axis high byte
YGYRO_LOW	0x18	R	\	0	Gyro Y-axis low byte
ZGYRO_HIGH	0x1A	R	\	0	Gyro Z-axis high byte

ZGYRO_LOW	0x1C	R	\	0	Gyro Z-axis low byte
XACCEL_HIGH	0x1E	R	\	0	Accel X-axis high byte
XACCEL_LOW	0x20	R	\	0	Accel X-axis low byte
YACCEL_HIGH	0x22	R	\	0	Accel Y-axis high byte
YACCEL_LOW	0x24	R	\	0	Accel Y-axis low byte
ZACCEL_HIGH	0x26	R	\	0	Accel Z-axis high byte
ZACCEL_LOW	0x28	R	\	0	Accel Z-axis low byte

7.3.4.1 SPI BURST Register

BURST is a sequential read register that reads all data in a single stream with no stopping between each 16-bit segment.

Table 32 SPI BURST Register Format

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

The BURST read method is as follows: send 0x8000 to set BURST and start reading, then send 0x0000 all the time to receive the data. The output register content is offset by 2 SPI cycles from the reading instructions sent, and the chip select stays low all the time during the reading period.

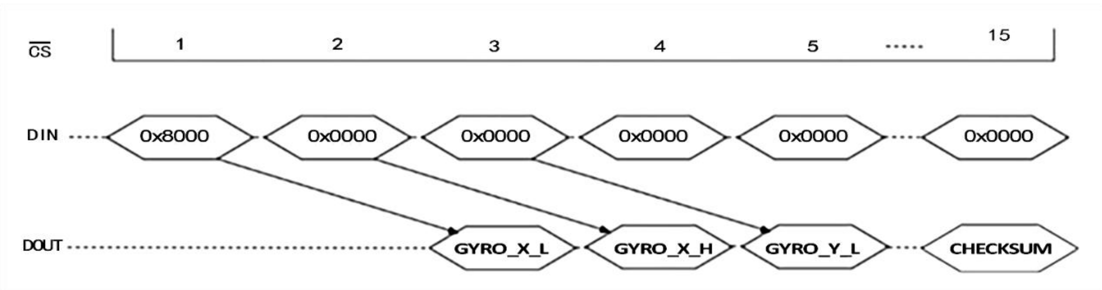


Fig. 20 SPI BURST Continuous Reading Diagram

Table 33 SPI BURST Sequential Read Basic Format

Transmit sequence	1	2	3	4	5	6
Transmit content	GYRO_X_L	GYRO_X_H	GYRO_Y_L	GYRO_Y_H	GYRO_Z_L	GYRO_Z_H
Transmit sequence	7	8	9	10	11	12
Transmit content	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H	ACCL_Z_L	ACCL_Z_H
Transmit sequence	13					
Transmit content	CHKSM					

Note 1: All data are in 16-bit width.

Note 2: The data from the gyroscope and accelerometer are spliced together and represented in the int32 format.

Note 3: CHKSM is CHECKSUM, which is used to confirm data integrity. The calculation method is to sum up all the data before CHECKSUM.

In the BURST continuous reading process, the 32-bit complete data is split into high 16-bit and low 16-bit output respectively, and the output adopts the little-endian mode, that is, the low byte outputs first. Users need to splice these two parts of 16-bit data to restore the complete 32-bit data.

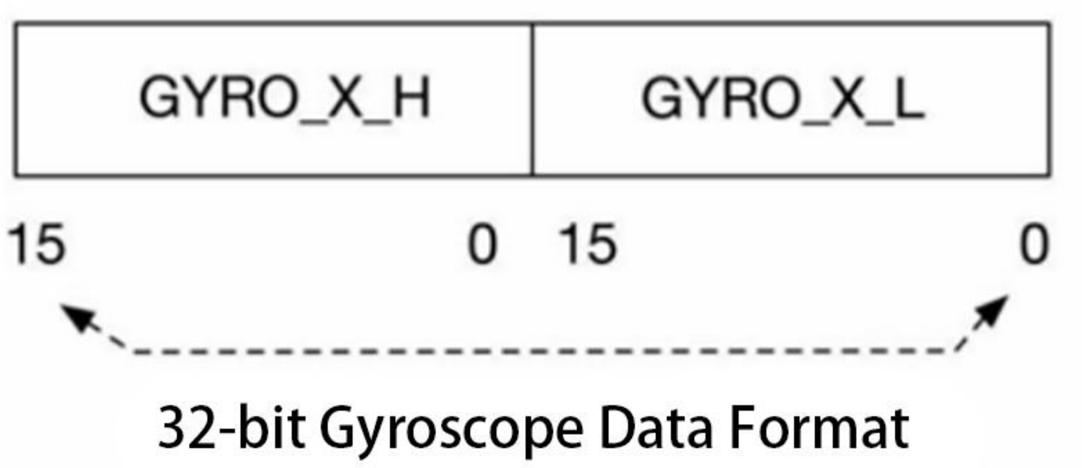


Fig. 21 SPI 32-bit Data Restoration Diagram

After acquiring the complete 32-bit data, standard frame users can get the information of angular velocity, acceleration, temperature and attitude angle by applying the following formulas.

Table 34 Standard Frame SPI 32-bit Data Conversion Formulas

Name	**Unit**	**Formulas**	**Conditions/Remarks**
Angular velocity	°/s	G=SF/65536*GYRO	GYRO represents 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 represents the ACCL data for the X, Y, and Z axes in the table above. Burst mode, SF = 0.2 SF = 0.2/1000 in single register mode.
Temperature	°C	T=SF/65536*TEMP-172621824+25	TEMP represents the TEMP data in the table above. Temperature scale factor SF=-1/263.4
Attitude angle	°	D=SF/65536*ATT	ATT represents 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 users with the control of digital low-pass filters. This register is readable/writable. The write command is to send 0x86XX and the current SPI cycle setup is valid; the read command is to send 0x0600 and the output register content is offset by 2 SPI cycles from the read command sent.

Table 35 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				Gyroscope filter configuration				RW

Table 36 Filter configuration

	Encode	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: e.g. configuring the gyroscope and accelerometer filters to be 10Hz, write the value 0x8644.

7.3.4.3 SPI ID Register

ID register is a read-only register, the data content is the character "IMU" encoded in ASCII, and the read method is similar to BURST data reading: send 0x6C00~0x7000 when reading, and receive data. The output register content is offset by 2 cycles from the read command sent.

Splicing 4 16-bit ID data into ASICII code to obtain the complete ID of the product. The splicing method is the same as that of BURST continuous read data, with PROD_ID1 in the high bit and PROD_ID4 in the low bit.

Table 37 SPI ID Register Format

Address	**bit15 ~ bit0**	**Encode**	**Read/Write**
0x6C	PROD_ID1	0x494D	R
0X6E	PROD_ID2	0x5536	R
0x70	PROD_ID3 The code 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 and switch window ID and it is readable and writable. The window defaults to 0. Switch window ID to 1 if writing 0xFE01.

Table 38 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 39 SPI Register WIN_CTRL.WINDOW_ID Encoding

Name	Encode	Description
WINDOW_ID	0x00	Window0, start reading data
	0x01	Window1, enter configuration mode

7.4 Common AT Commands

7.4.1 Stop the Current Data Stream Output

Command: AT+SETNO\r\n

Response: OK

The current data flow can be stopped (without changing the parameters), when the output is OK, it indicates that it's OK to proceed the next step.

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

Enable data stream output:

Command: AT+SETYES\r\n

7.4.2 Querying Version Numbers

Command: AT+VERSION\r\n

Response: SW_VERSION Firmware version HW_VERSION Hardware version BOARD_VERSION Baseboard Version

OK

7.4.3 Querying User ParametersCommand:

AT+CONFIG\r\n
Response: BAUD_RATE Current serial port baud rate
ORIENT Current coordinate system
IMU_ODR Current IMU output
STREAM_MODE1 Current data flow mode of serial port 1
STREAM_MODE2 Current data flow mode of serial port 2
STREAM_MODE3 Current data flow mode of serial port 3
LP_CONFIG_REG Current IMU filtering

OK

7.4.4 Setting and Querying the ODRs

Example: Set the output frequency ODR to 50hz
Command: AT+SET_ODR=50\r\n
Response: IMU_ODR:50

OK

Query the IMU’s ODR

Command: AT+GET_ODR\r\n

Respond: IMU_ODR:50

OK

7.4.5 Setting and Querying the Coordinate System

Example: Set the IMU coordinate system to Front-Right-Up

Command: AT+SET_ORIENT=101\r\n

Response: orientation:101

OK

Query IMU's current coordinate system

Command: AT+GET_ORIENT\r\n

Response: orientation:101

OK

7.4.6 Setting and Querying Baud Rates

Example: Set the IMU's baud rate 115200

Command: AT+SET_BAUD=115200\r\n

Response: OK

Query IMU's current baud rate

Command: AT+GET_BAUD\r\n

Response: BAUD_RATE:115200

OK

7.4.7 Setting the Reverse Roll and Pitch

If AT+SET_ATT_ORIENTATION=00\r\n, then roll and pitch angles are not reversed.

If AT+SET_ATT_ORIENTATION=01\r\n, then roll angle is reversed while pitch angle is not reversed.

If AT+SET_ATT_ORIENTATION=10\r\n, then roll angle is not reversed while pitch angle is reversed.

If AT+SET_ATT_ORIENTATION=11\r\n, then roll and pitch angles are reversed.

7.4.8 Setting and Querying Filters

Example: Set the IMU's filtering to 20Hz

Command: AT+SET_LPF=102\r\n

Response: LP_CONFIG_REG:102

OK

Query the IMU's current filtering

Command: AT+GET_LPF\r\n

Response: LP_CONFIG_REG: 102

OK

Table 40 Low-pass filter value and corresponding value of AT command

No.	IMU Low-pass filter value	Corresponding value of AT command
1	1	17
2	2	34
3	5	51
4	10	68
4	15	85
5	20	102
6	25	119
7	30	136
8	35	153
9	40	170
10	47 (without filter value)	187

7.4.9 Save Parameters

Command: AT+SAVE\r\n
Response: OK

7.5 CAN Communication Protocols

Examples of how a STM32-based CAN host reads driver:

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

7.5.1 Communication Parameters

Interface type: CAN, standard frame

CAN rate: 250Kbps~1Mbps (configurable)

7.5.2 Standard Frame Format

Table 41 CAN Standard Frame Format 101

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

Table 42 CAN Standard Frame Format 102

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

Table 43 CAN Standard Frame Format 103

Standard Frame ID	1	2	3	4	5	6	7	8
0x67+ nodes	Gy				Gz			

Table 44 CAN Standard Frame Format 104

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

Table 45 CAN Standard Frame Format 105

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

Note 1: The data of attitude angle, gyroscope, and accelerometer are expressed as float, while the data of temperature and count value are expressed as int16.

Note 2: The unit of TEMP is 100*°C, the unit of gyroscope output is °/s, the unit of accelerometer output is g, and the unit of attitude output is °.

7.6 Parameters Setting

7.6.1 Setting and Querying Baud Rates

Setting Can's Baud Rate, Command:

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

IMU responds as follows:

Id=0x519, DATA=0xXX 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Query CAN's baud rate, command:

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

IMU responds as follows:

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

In which:

When XX=01; Baud Rate=250 Kbps

When XX=02; Baud Rate=500 Kbps

When XX=03; Baud Rate=1000 Kbps

7.6.2 Setting Nodes ID

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

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

IMU responds as follows:

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

7.6.3 Querying Version Numbers

Command:

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

IMU responds as follows:

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

Version Number: 0X0003120E, i.e. firmware version number: 201230

7.6.4 Querying / Setting Terminal Resistance

Without Terminal Resistance, command:

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

IMU responds as follows:

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

With Terminal Resistance, command:

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

IMU responds as follows:

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

7.6.5 Setting Output Frequency

Setting output frequency, command:

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

IMU responds as follows:

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

Querying output frequency, command:

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

IMU responds as follows:

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

In which:

When XX=01, output frequency = 1HZ

When XX=02, output frequency = 10HZ

When XX=03, output frequency = 50HZ

When XX=04, output frequency = 100HZ

When XX=05, output frequency = 200HZ

7.6.6 Setting and Querying The Reverse Raw&Pitch

Setting reverse raw&pitch, command:

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

IMU responds as follows:

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

Querying the status of reverse raw&pitch, command:

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

IMU responds as follows:

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

In which:

When XXXX=0X00, roll and pitch angles are not reversed.

When XXXX=0X01, roll and pitch angles are not reversed.

When XXXX=0X10, roll angle is not reversed while pitch angle is reversed

When XXXX=0X11, roll angle is not reversed while pitch angle is reversed

7.6.7 Configure the Filter Cutoff Frequency

Setting Filter Cutoff Frequency, command:

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

IMU responds as follows:

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

Querying the status of Filter Cut-off Frequency, command:

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

IMU responds as follows:

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

In which:

XXXX=0X44, cut-off frequency is 10HZ

XXXX=0X66, cut-off frequency is 20HZ

XXXX=0XAA, cut-off frequency is 40HZ

XXXX=0XBB, cut-off frequency is 47HZ

7.6.8 Setting and Querying the Coordinate System

Setting the coordinate system, command:

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

IMU responds as follows:

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

Querying orientation, command:

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

IMU responds as follows:

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

In which:

When XXXX=0X65, default orientation

CAN is configured in hexadecimal, while chapter 8 shows decimal. Please go to chapter 8 for specific orientation settings

7.6.9 Closing and Deducting Attitude Angle

Setting to deduct the misalignment of the attitude angle, command:

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

IMU responds as follows:

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

Querying whether the attitude angle setting is deducted, command:

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

IMU responds as follows:

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

In which:

When XXXX=0X01, the attitude angle is deducted;

When XXXX=0X00, the attitude angle is not deducted.

7.6.10 Save Command

Sent command:

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

IMU responds as follows:

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

The message will be returned only after the saving is completed, and taken effect after rebooting.

8 Definition of Coordinate System

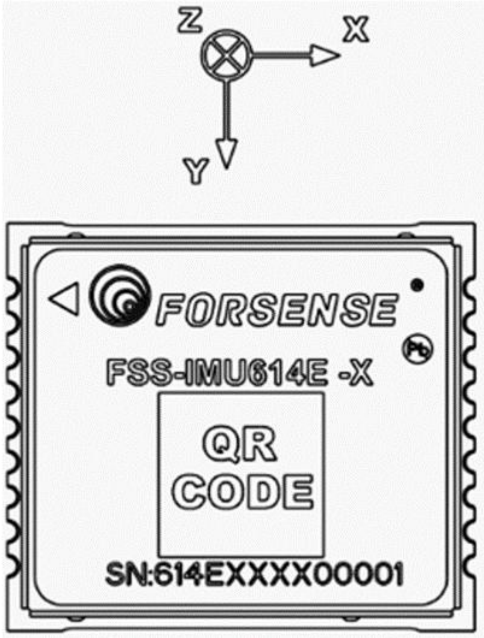


Fig. 22 Definition of Coordinate System

This product is equipped with the Front-Right-Down (FRD) coordinate system, and the range of Euler angles is as follows:

Rotate around Z-axis: Yaw angle: 0° ~360°

Rotate around X-axis: Roll angle: -180°~180°

Rotate around Y-axis: Pitch angle: -90°~90°

The diagram of roll, pitch, and yaw Angles are as follows:

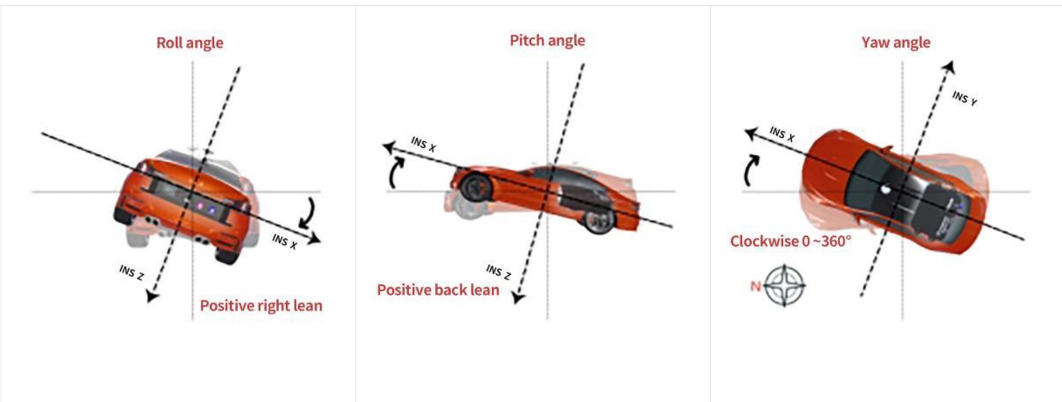


Fig. 23 Diagram of Roll, Pitch, and Yaw Angles

9 CRC Look-up Table Calculations

It is recommended to refer directly to the sample code.

Note 1: The data is transmitted in little-endian format, with low byte first and then high byte.

Note 2: The initial value of crc32 is 1 and the CRC calculation does not include all the data of the frame itself.

```
C++
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;
}
```

10 Usage Examples

10.1 Device Installation

1. The module should be firmly fixed on a rigid plane rather than in a position of high vibration;

2. The module should be installed toward the front of the vehicle;

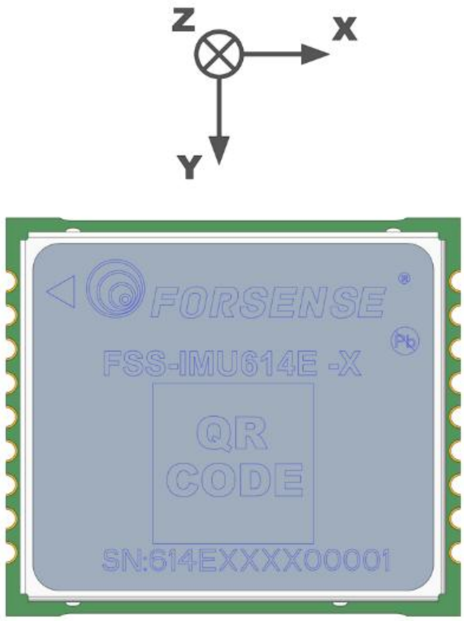


Fig. 24 Module Installation Diagram

The correct installation method is as follows

X-axis toward the front of the vehicle

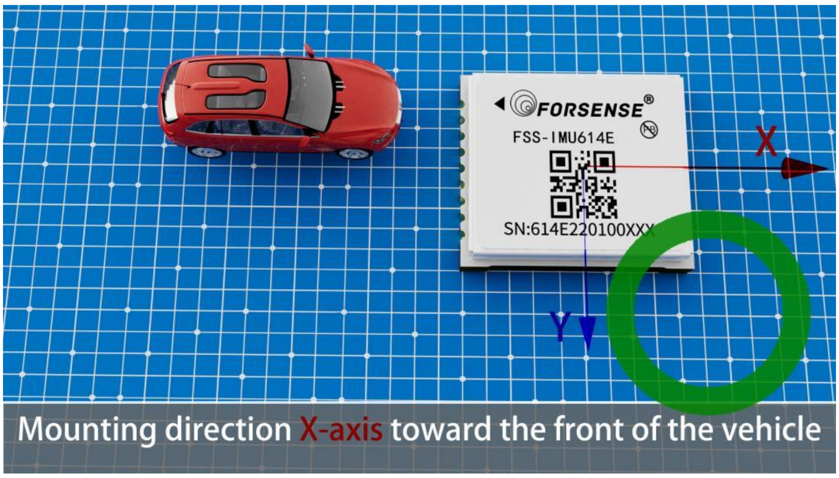


Fig. 25 Correct Installation Diagram

The following mounting methods are incorrect:

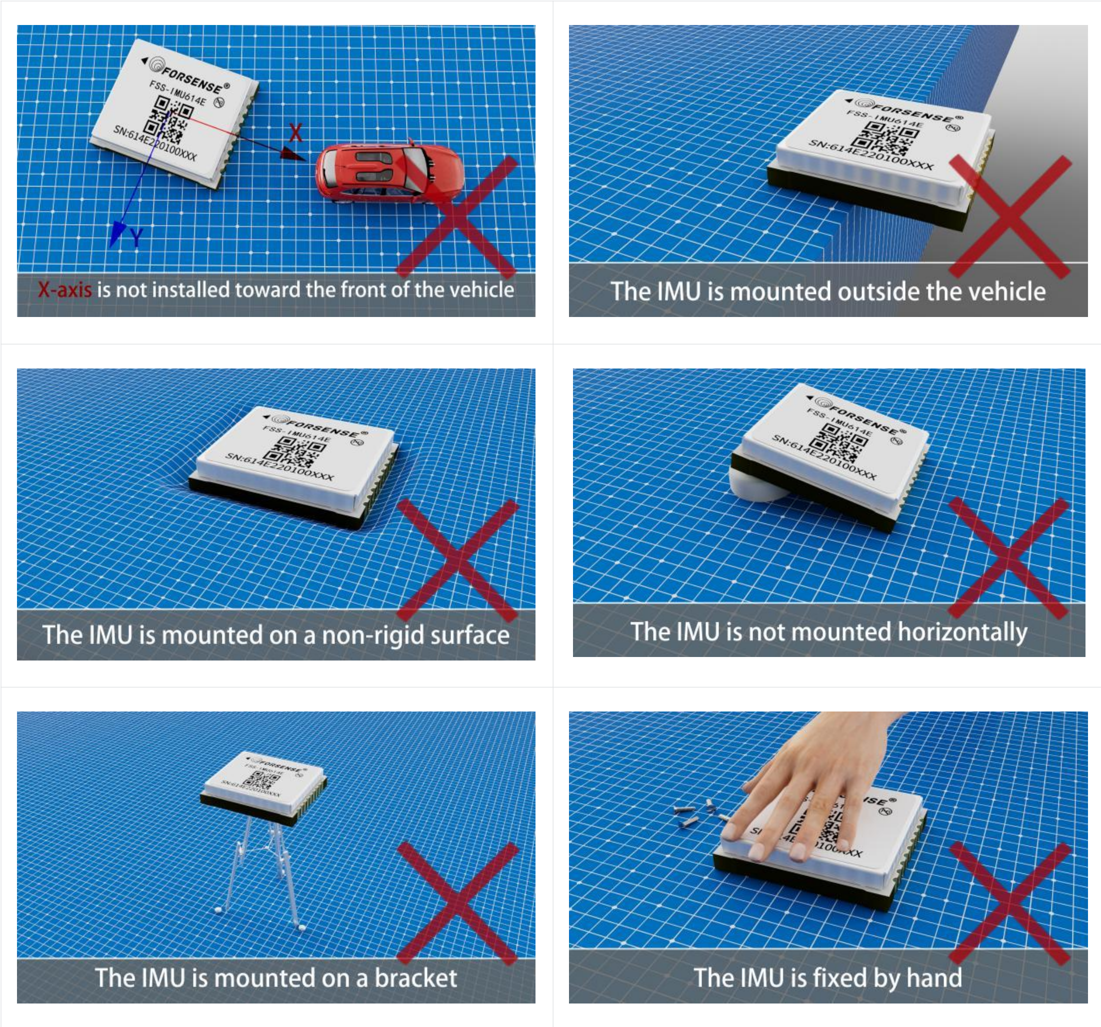


Fig. 26 Wrong Module Installation Diagram

3. IMU Installation Precautions

No glue or other liquids around the IMU to prevent them from flowing into the interior of the IMU through gaps, thus impairing performance of the IMU.

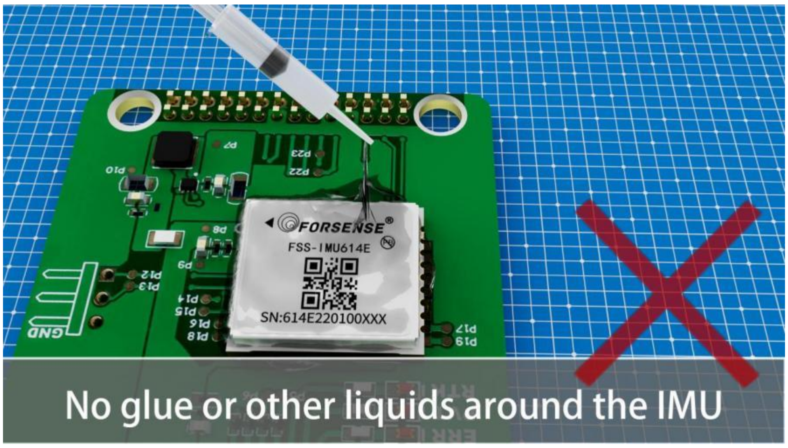
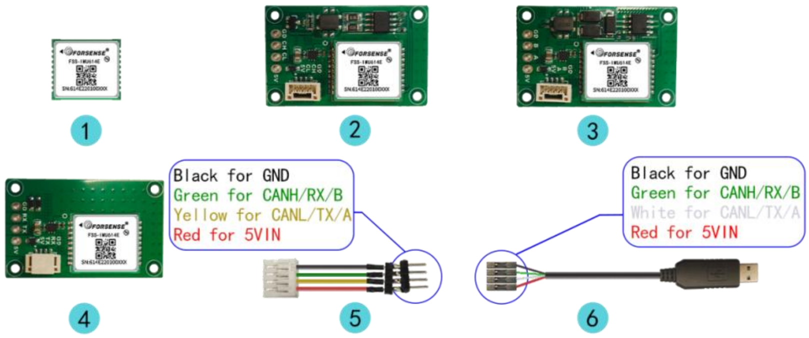
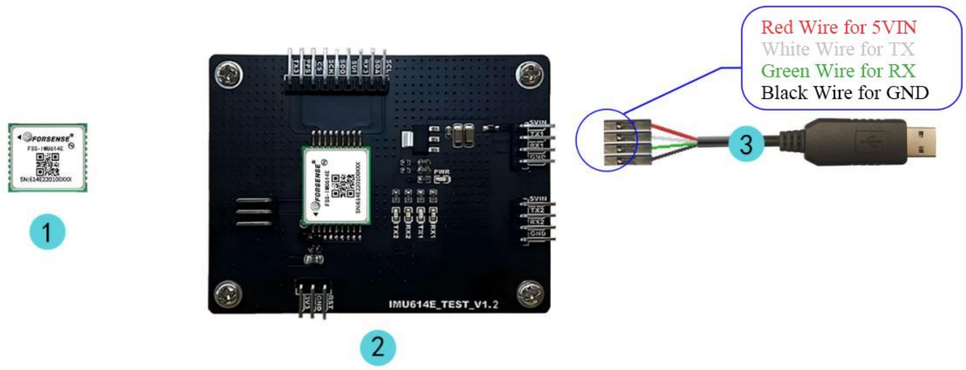


Fig. 27 Wrong Installation Diagram

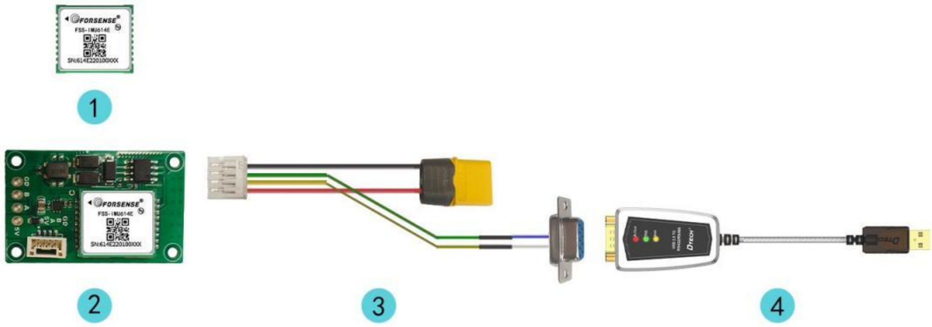
10.2 Connecting PC software



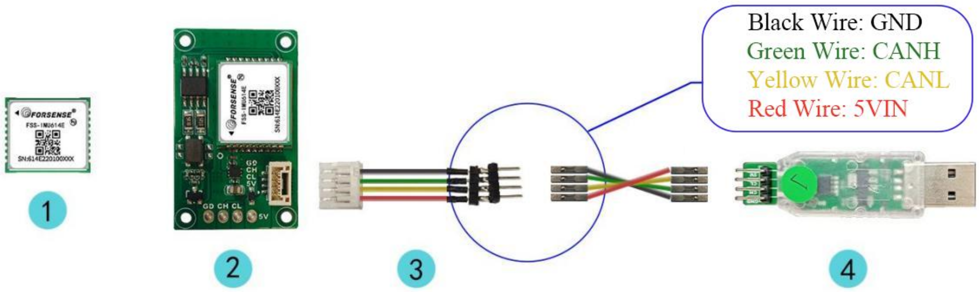
	Name	Quantity
1	IMU 614E Series Module	1
	Accessories Name	**Quantity**
2	CAN Test Substrates	1
3	RS485 Test Substrates	1
4	TTL Test Substrates	1
5	4-PIN Connector	1
6	TTL Serial Cable	1



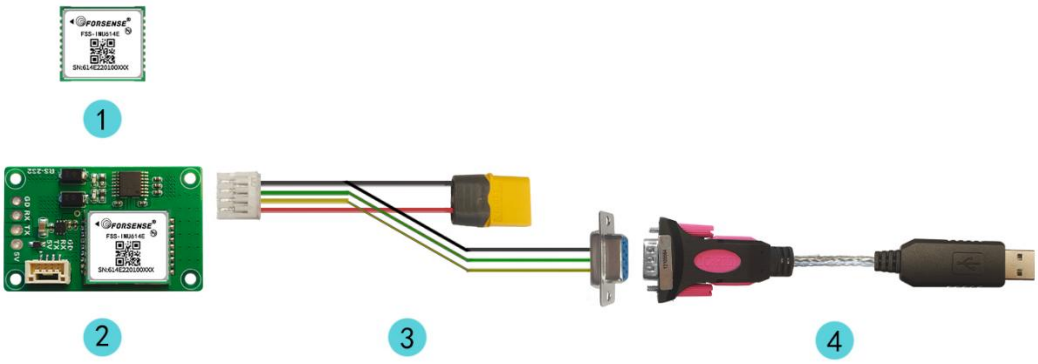
	Name	Quantity
1	IMU614E Series Module	1
	Accessory Name	Quantity
2	New IMU614E Test Substrate	1
3	TTL Serial Cable	1



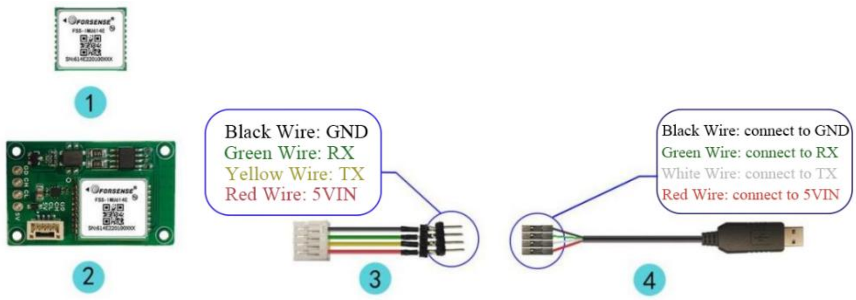
	Name	Quantity
1	IMU614E Series Module	1
	Accessory Name	Quantity
2	RS485 Test Substrate	1
3	RS485 Test Substrate Harness	1
4	USB Conversion Cable	1



	Name	Quantity
1	IMU614E Series Module	1
	Accessory Name	Quantity
2	CAN Test Substrate	1
3	4-PIN Connector	1
4	TTL Serial Cable	1



	Name	Quantity
1	IMU614E Series Module	1
	Accessories Name	Quantity
2	RS232 Test Board	1
3	RS232 Test Harness	1
4	RS232 Serial Cable	1



	Name	Quantity
1	IMU614E Series Module	1
	Accessory Name	Quantity
2	TTL Test Substrate	1
3	4-PIN Connector	1
4	TTL Serial Cable	1

11 Packaging

The IMU614E-UAV module is packaged in sealed tape and reel, which contributes to efficient production. Enables efficient production.

11.1 Tape and Reel Packaging

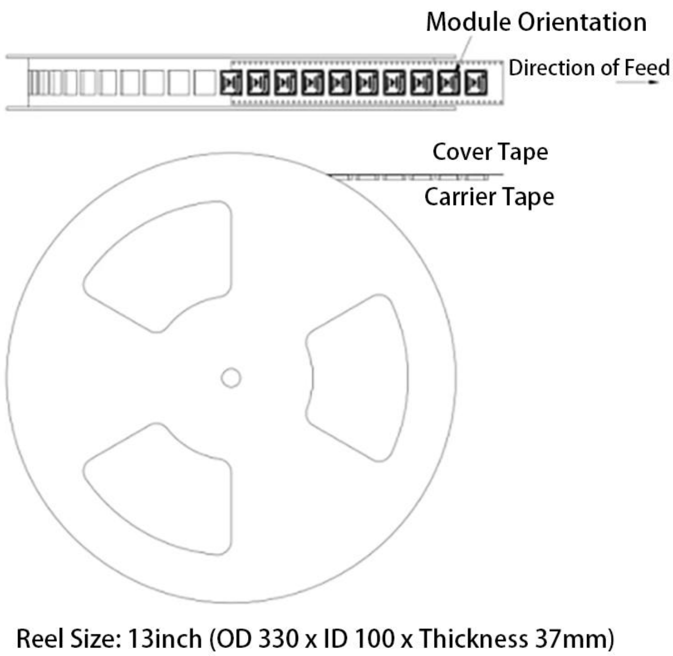


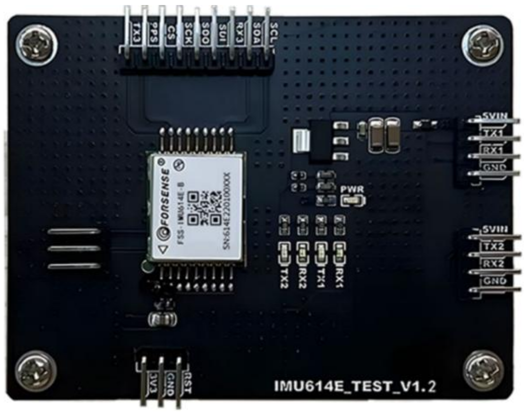
Fig. 29 Tape and Reel Packaging Diagram

11.2 Carrier Tape

The IMU614E-UAV module is placed on the carrier tape in the position and orientation shown below before leaving the factory:

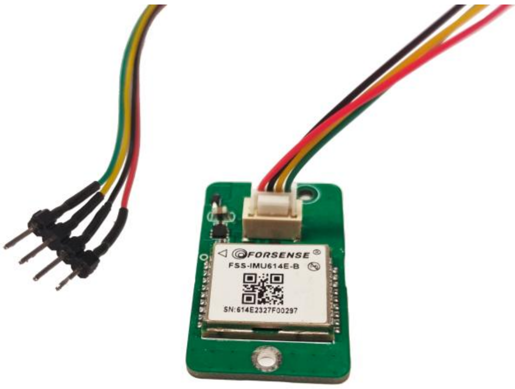
Fig. 30 Module Position and Orientation on Carrier Tape

12 Accessories



IMU614E-X Test Base Plate (New Version)

SMD CAN IMU614E Series



SMD TTL IMU614E Series

SMD 485 Version IMU614E Series

USB to CAN Module

TTL Serial Cable

13 Revision History

Version	Date	Status/Notes
Version 1.0	08/26/2024	First Edition
Version 1.1	01/23/2025	Adjusted table, figure sequence and section