FORSENSE
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Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-U

Product manual



Forsense (Shanghai) Technology Co., Ltd

Please read this user manual carefully before using this product.

FORSENSE
原极科技

Tactical-grade MEMS 6-DOF inertial sensor

FSS-IMU614E-U-Product Manual(en)

Features

Tactical-Grade MEMS Gyroscope

- 5.5 °/hr Bias instability
- 0.25 °/√hr Angle Random Walk

Tactical-Grade MEMS Accelerometer

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

independent rotary table calibration

- Independent calibration of each module: sensitivity, Bias, Misalignment
- -40°C to 85°C temperature compensation

High-intensity operating condition tolerance

- Extreme shock resistance: 2000g (0.5ms, half-sine, 3-axis)
- Extreme vibration resistance: 10g (10~2kHz, 3-axis)
- Stable operation across full temperature range: -40°C ~ 85°C
- 100% magnetic shielding

Real-time and flexible digital interface, compact size

- Configurable Output Sampling Rate up to 1kHz
- Supports Serial Port, I2C, and SPI Interfaces
- 14.7*17*3.3mm, Weighing Only 1.6g

Product Overview

IMU614E-Uis a 6 degrees of freedom (DOF) MEMS Inertial Sensor Module meticulously crafted by Forsense Technology. It standardly outputs three-axis Gyroscope and acceleration data.

High precision and high resolution capture subtle vibrations and tilts. All modules undergo turntable calibration before shipment, ensuring stable performance under extreme conditions and high consistency across all products.

Application Areas

- UAV
- Flight Controller

Based on standard performance and output Parameter, Forsense also offers**customized software and LOGO customization services** to support your product needs!

Table of Contents

1. Performance Parameter **4**
1.1 1.1 Gyroscope Key Metrics 4
1.2 1.2 Key Metrics of Accelerometer 5
2. Physical Structure **7**
3. Electrical Characteristics **9**
3.1 Maximum Ratings 9
3.2 Operating Conditions 9
3.3 IO Threshold Characteristics 10
4. Pin Definition **11**
5. Recommended Reflow Soldering Temperature Profile **14**
6. ESD Protection **16**
7. Communication Protocol **17**
7.1 serial communication protocols 17
7.1.1 serial port parameters 17
7.1.2 Packet Format 17
7.1.3 Data Stream Frame — AHRS Data 18
7.1.4 Command Mode GET Output — System Status 20
7.1.5 Command Mode GET Output — Read Parameter 21
7.1.6 Command Mode SET Command 23
7.1.7 Command Mode Output — User Command Response 26
7.1.8 DRDY 28
7.1.9 Coordinate System Configuration 29
7.1.10 Serial Port Connect FAQs 33
7.2 I2C Communication Protocol 35
7.2.1 I2C Interface Parameter 35
7.2.2 I2C Connection Method 35
7.2.3 I2C Register 36
7.2.3.1 I2C BURST Register 36
7.2.3.2 I2C FILTER_CTRL Register 38
7.2.3.3 I2C ID Register 38
7.3 SPI Communication Protocol 39
7.3.1 SPI Interface Parameter 39
7.3.2 SPI Connection Diagram 39
7.3.3 SPI Communication bit sequence 40
7.3.4 SPI Register 41
7.3.4.1 SPI BURST Register 42
7.3.4.2 SPI FILTER_CTRL Register 44
7.3.4.3 SPI ID Register 45
7.3.4.4 SPI WIN_CTRL Register 46
7.4 Common AT Commands 47
7.4.1 Stop Current Data Stream Output 47
7.4.2 Query Version Number 47
7.4.3 Query User Parameter 47
7.4.4 Set and Query ODR 48
7.4.5 Set and Query Coordinate System 48
7.4.6 Set and Query Baud Rate 48
7.4.7 Set Roll and Pitch Inversion 48
7.4.8 Set and Query Filter 49
7.4.9 Save Parameter 49

7.5 CAN Communication Protocol 50
7.5.1 Communication Parameter 50
7.5.2 Standard Frame Format 50
7.5.3 CAN Parameter Configuration 51
7.5.3.1 Configure CAN Baud Rate 51
7.5.3.2 Configure Node ID 52
7.5.3.3 Query Version Number 52
7.5.3.4 Query/Set Terminal Resistor 52
7.5.3.5 Set Output Frequency 52
7.5.3.6 Query/Set Roll and Pitch Inversion 53
7.5.3.7 Query/Set Filter Cutoff Frequency 54
7.5.3.8 Query/Set Coordinate System 54
7.5.3.9 Disable/Deduct Attitude Angles 55
7.5.3.10 Save Command 55
8. Coordinate System Definition 56
9. CRC Calculation Using Lookup Table 58
10. Usage Example 60
10.1 Device Installation 60
10.2 Connection PC software Example 63
11. Packaging 68
11.1 Tape-and-Reel Packaging 68
11.2 carrier tape 68
12. Optional AccessoriesAccessories 70
13. UpdateRecord 72

1. Performance Parameter

1.1 1.1 Gyroscope Key Metrics

Table 1 Key Metrics of Gyroscope

Parameter	Test Conditions / Remarks	Min	Typical	Max	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
Misalignment between axes			0.02		deg
Internal low-pass cutoff frequency	Software Adjustable		50		Hz
ODR			1000		Hz
measure delay			5.5		ms
Bias 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, provided by the Allan variance curve under static conditions at 25°C

Note 2: 1σ value of Bias variation over the full temperature range with a heating rate of 1°C/min

1.2 1.2 Key Metrics of Accelerometer

Table 2 Key Metrics of Accelerometer

Parameter	Test Conditions/Notes	Min	Typical	Max	Unit
Measurement Range			±32		g
Bias instability[1]	@25℃, 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	Software Adjustable		50		Hz
ODR			1000		Hz
measure delay			5.5		ms
Bias over temperature[2]	-40℃ ~ 85℃, ≤1℃/min @1σ		1.5		mg
Random Walk[1]	@25℃, Allan Variance, 1σ		0.03		m/s/√hr
scale coefficient error	@25℃, 1σ		1.5		‰
scale factor nonlinear			100		ppm

Note 1: IEEE standard, ALLAN variance curve provided under static conditions at 25°C

Note 2: 1σ value of Bias variation over the full temperature range at a heating rate of 1°C/min

Figure 1 Typical Gyroscope Allan Variance Curve

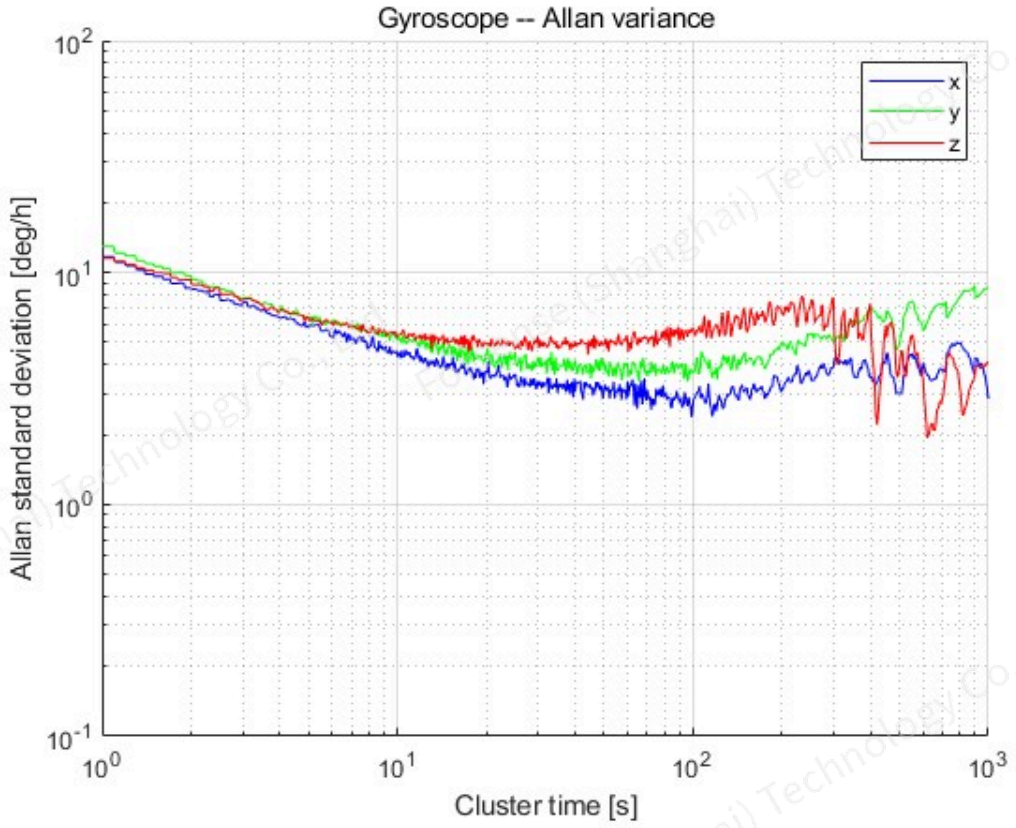
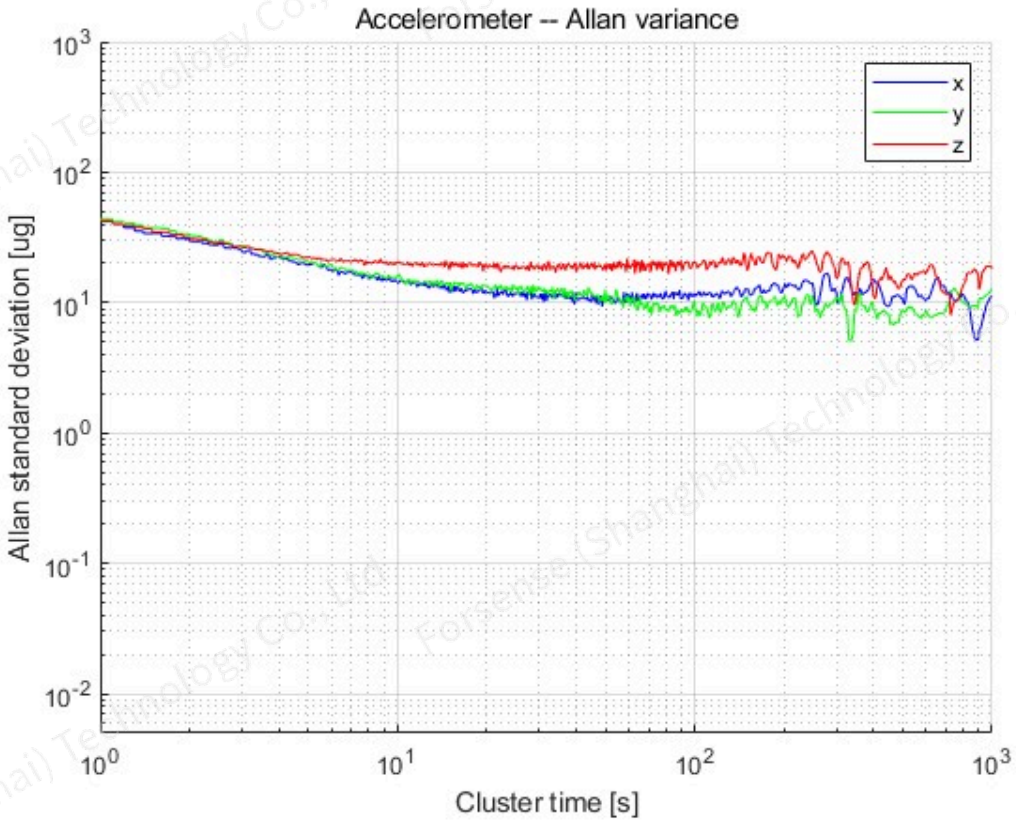
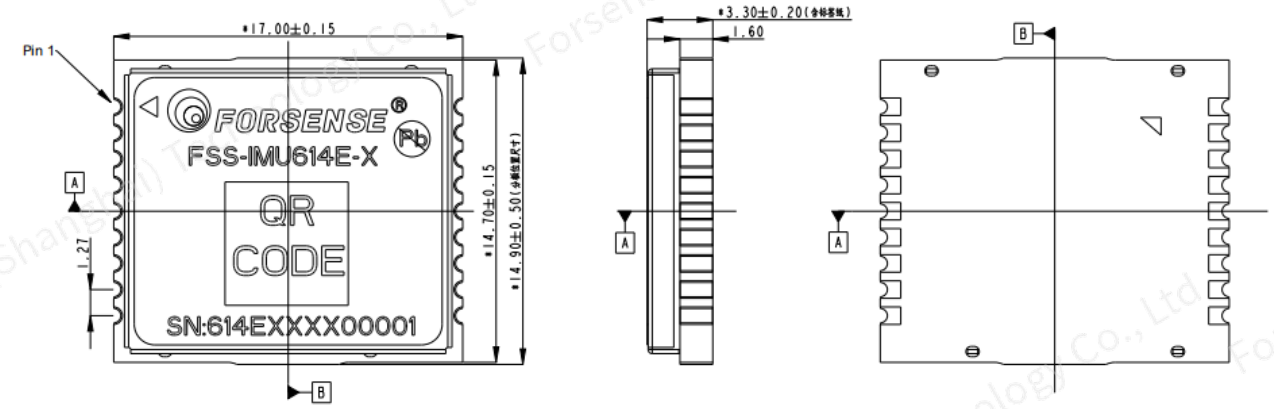


Figure 2 Accelerometer Allan Variance Typical Curves



2. Physical Structure

Figure 3 Outline Structure andRecommended PadsDimensions (Unit: mm)



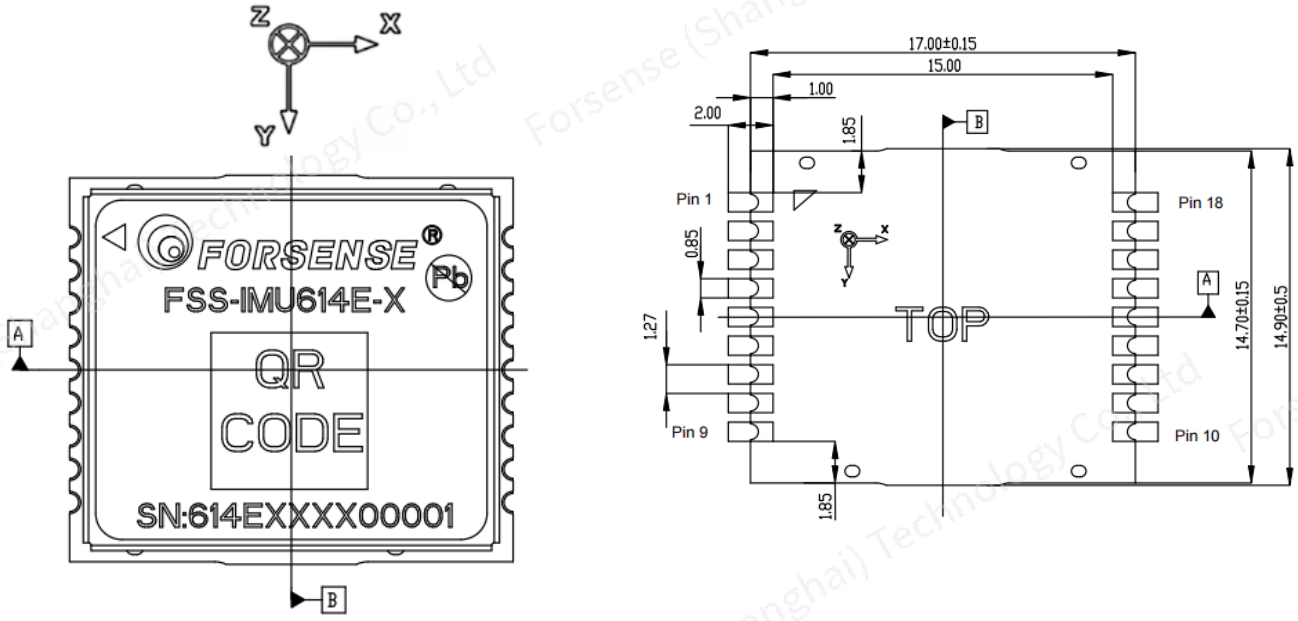
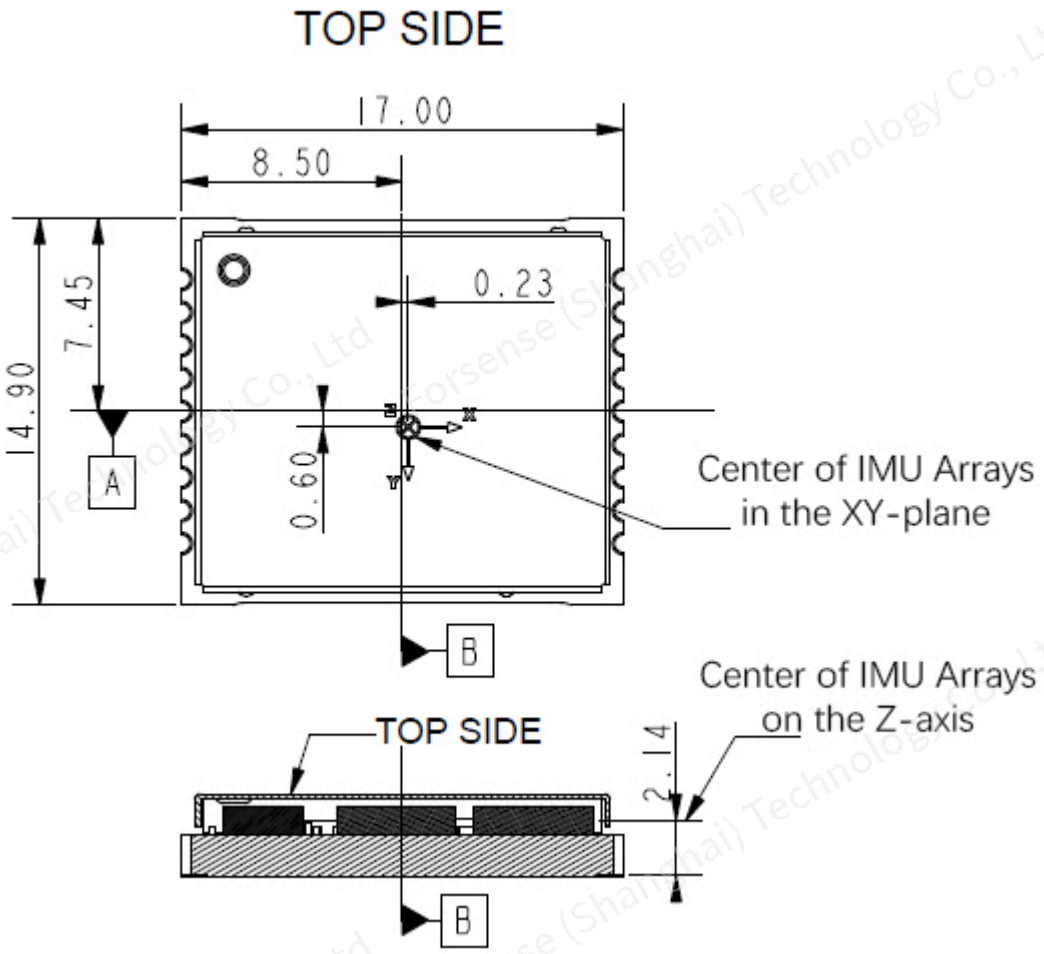


Figure 4 IMU Coordinate Center (Unit: mm)


TOP SIDE
17.00
8.50
7.45
14.90
0.23
0.60
A
B
Center of IMU Arrays
in the XY-plane
TOP SIDE
2.14
Center of IMU Arrays
on the Z-axis
B

3. Electrical Characteristics

3.1 Maximum Ratings

Table 3 Absolute Maximum Ratings

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

3.2 Operating Conditions

Table 4 Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
supply voltage	VCC	3.2	3.3	3.4	V
VCC Max Ripple	Vrpp		±40		mV
Power Consumption	P		0.13		W
Operating Temperature (Tot)	T	-40		85	℃
Storage Temperature (Tstg)	T	-40		85	℃

3.3 IO Threshold Characteristics

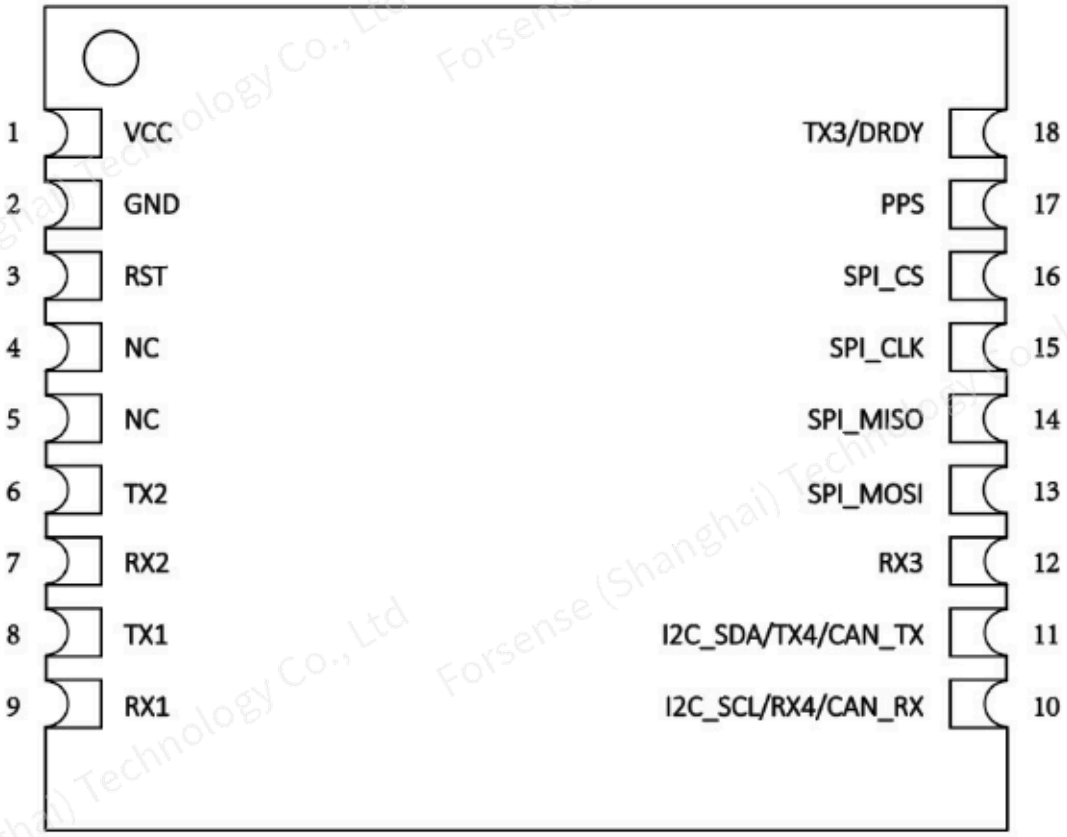
Table 5 IO Threshold Characteristics

Parameter	Symbol	Minimum	Typical Value	Maximum Value	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 power level	Vout_low	0		0.45	V
Output Pin High power level	Vout_high	VCC-0.45		VCC	V

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4. Pin Definition

Figure 5 Pin Schematic



IMU614E-X Pin Layout (Top View)

Table 6 Pin Definitions

Pin No.	Pin Name	Pin Description		
1	VCC	Power Input, +3.3V Input, 40mA, Ripple ≤ ±40mV		
2	GND	Ground (GND)		
3	RST [1]	External Hardware Reset Input, Internal Pull-up (for SPI Mode)		
4	NC	No Connection		
5	NC	No Connection		
6	TX2	Receive asynchronous data Output		
7	RX2	Receive asynchronous data Input		
8	TX1	Receive asynchronous data Output (Data Communication Interface (LVTTL))		
9	RX1	Receive asynchronous data Input (Data Communication Interface (LVTTL))		
10	CAN RX / RX4 / I2C_SCL	Mode	Function	Description
		1	CAN_RX	CAN receives Pin; Read data from the bus to the CAN controller
		2	RX4	Receive asynchronous data input
		3	I2C_SCL	I2C serial clock
11	CAN TX / TX4 / I2C_SDA	Mode	Function	Description
		1	CAN_TX	CAN Send Pin; Read Data from CAN Controller to 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 Input		
14	SPI_MISO	SPI serial data Output		

15	SPI_CLK	SPI serial clock
16	SPI_CS	SPI chip select
17	PPS	External Synchronous Sampling Trigger Signal; (Connect to RTK PPS Pin)
18	TX3/DRDY	Receives asynchronous data Output / Can Be Used For Data Ready

Note 1: When Master initialize, Use /RST To Reset The IMU Hardware Once

For hardware design information related to the module, refer to the document《IMU614E-XX Hardware Design Manual》.

5. Recommended Reflow Soldering Temperature Profile

Figure 6 Reflow Soldering Temperature Profile

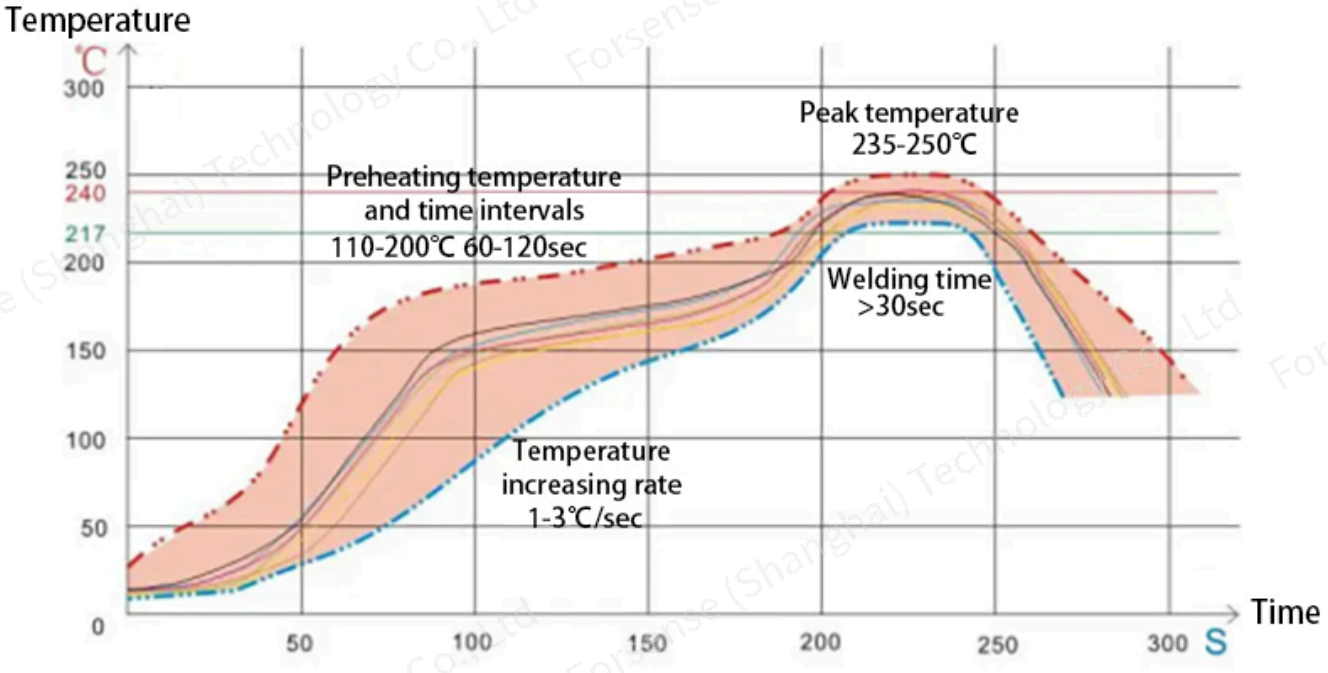


Table 7 Temperature Setting Modes

Item	Lower Limit	Upper Limit	Unit
Maximum Temperature Ramp Rate (Target = 0.8) (Time interval for slope calculation = 60 s)	1	3	°/s
Maximum Temperature Drop Slope (Time interval for slope calculation = 60 s)	-3	-1	°/s
Preheat Temperature and Time Interval	60	120	s
Reflow Time (Duration above 217°C)	40	70	Second
Maximum Temperature	235	250	°C
Max Reflow Count		1	Times

For more SMT-related information about the module, refer to the document《Forsense-LCC Module_SMT Application Guide》.

Notes:

- For module reflow soldering, it is recommended to use eight temperature zones or higher reflow soldering equipment;
- Since the module is a high-precision sensor product, it is sensitive to any deformation:
- If the PCB thickness is less than 1.0 mm, it is recommended to fabricate reflow fixture to prevent PCB deformation at high temperatures, which may affect soldering coplanarity.
- It is recommended that customers select high TG value materials for the main PCB to avoid deformation during high-temperature reflow, which can cause warping, compression, cold joints, and bridging defects.
- Due to sensitive components inside the module, the maximum temperature of the customer's reflow oven must not exceed 260°C (referring to the top package temperature measured on the package surface).
- Lead-free no-clean solder paste is recommended. Recommended solder paste brands and models: Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5
- Due to sensitive components inside the module, secondary reflow should be avoided to prevent performance degradation;
- Cooling:
- Controlled cooling ramp rate prevents adverse soldering effects (such as brittle joints) and internal mechanical stress. Controlled cooling helps achieve bright solder surfaces, fine crystal grains, and low contact angles, while avoiding shielding can warpage caused by rapid temperature drops.
- Visual Inspection:
- After module soldering, inspect solder quality using X-ray and optical magnification methods. Refer to the relevant IPC-A-610F standards for details.
- **When soldering with a soldering iron, control the temperature between 260°C and 290°C, limit single soldering time to no more than 3 s, and ensure proper ESD protection.**

6. ESD Protection

Figure 7 ESD Protection



Static electricity causes intermittent or permanent circuit damage and poses significant risks to electronic products. Analysis indicates that most failures are due to ESD damage;

Therefore, electrostatic protection for the module is critical. Production and transportation must strictly follow ESD protection procedures, adhering to the following conditions:

- Bare-hand contact with the module is strictly prohibited, especially at Pin.
- Equipment such as SMT placement machines, workbenches, and soldering irons must be grounded.
- Operators must wear anti-static wrist straps with proper grounding wires (cordless wrist straps are not allowed; anti-static gloves are recommended).
- Packaging materials and PCBs must be qualified anti-static materials.

7. Communication Protocol

7.1 serial communication protocols

Serial Port protocol examples based on QT, ROS, and STM32:

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

serial communication has two modes: Stream Mode (Stream Mode) and Command Mode (Command Mode). After the IMU completes power-on initialize, it enters the corresponding mode based on the mode value configured in Parameter.

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

Command Mode: In this mode, periodic output stops. The user communicates with the IMU by sending commands. Sensor data, status, Parameter, etc., can be retrieved via GET commands, and the IMU's Parameter can also be configured.

7.1.1 serial port parameters

Table8 serial port parameters

Transmission Rate Range	**115200bps ~ 1.5Mbps**
Default Transmission Rate	115200bps
Start Bit	1 bit
Data Bits	8 bits
Stop Bits	1 bit
Parity Check	None

7.1.2 Packet Format

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

Table 9 Data Structure of IMU Output and User Input

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 the serial communication frame ID
3		ID High Byte	High byte of the serial communication frame ID
4	uint16	Data Length Low Byte	Low byte of the serial communication frame length, length is the number of bytes occupied by the payload, i.e., n
5		High Byte of Data Length	High byte of serial communication frame length, length is the number of bytes occupied by the payload, i.e., n
6	uint8	Payload (n bytes)	Data Payload
6+n	Uint32	CRC_CEHCK (Low byte of 32-bit data)	CRC Check
7+n		CRC_CEHCK (Low Byte of 32-bit Data)	
8+n		CRC_CEHCK (High Byte of 32-bit Data)	
9+n		RC_CEHCK (Most Significant Byte of 32-bit Data)	

Note 1: Data is transmitted in little-endian format, with the low byte first and the high byte last

Note 2: The initial value of crc32 is 1. CRC calculation excludes itself and covers all data in the current frame. See the end of the document for the lookup table method.

7.1.3 Data Stream Frame — AHRS Data

Table 10 Serial Port AHRS Data Format

	Frame header	Frame header	ID	length	payload	Frame end
Data Type	uint8	uint8	uint16	uint16	A1	uint32
Encoding	0xAA	0x55	0x0002	0x002C		crc32

Note 1: The maximum output Update Rate is no greater than 200Hz@115200bps

Table 11 Serial Port A1 Payload Data Format

offset	Name	Data Type	Unit	Description
0	timer	uint32	μs	Time Stamp
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: Obtained AHRS data stream:

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

Parsed as follows:

Table 12 Serial Port A1 Obtained AHRS Data Stream

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 Stamp	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 Port System Status Data Format

	Frame header	Frame header	ID	length	payload	Frame end
Data Type	uint8	uint8	uint16	uint16	S1	uint32
Encoding	0xAA	0x55	0x00FF	N		crc32

Note 1: The length of this frame varies depending on the IMU model. It represents the length of S1 and must be confirmed based on the specific IMU model.

Table 14 Serial Port S1 Payload Data Format

offset	Name	Data Type	Description
0	Software_ver	uint32	Software Version
4	Hardware_ver	uint32	Hardware Version Number
8	rev	uint16	Reserved Bytes
10	sn0	uint32	First SN
14	sn1	uint32	Second SN
18	sn2	uint32	Third SN
22	Board_version	uint32	Base Plate Version Number
26	Rev[16]	Uint8	Subsequent bytes are reserved

Note 1: The number of subsequent reserved bytes varies by IMU model and must be confirmed based on the specific model; IMU614E has 16 bytes.

Example: Get 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 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

According to response data, the parsed software version is 211231 (1F 39 03 00) and the hardware version is 94053 (65 6F 01 00).

7.1.5 Command Mode GET Output — Read Parameter

Table 15 Serial Port Parameter Input Data Format

	Frame header	Frame header	ID	length	payload	Frame end
Data Type	uint8	uint8	uint16	uint16	P1	uint32
Encoding	0x55	0xAA	0x0006	0x0018		crc32

Table 16 Serial Port Parameter Output Data Format

	Frame header	Frame header	ID	length	payload	Frame end
Data Type	uint8	uint8	uint16	uint16	P1	uint32
Encoding	0xAA	0x55	0x7530	0x0018		crc32

Note 1: When reading Parameter, the IMU will close the data stream. The data stream needs to be reopened after configuration is complete.

Table 17 Serial Port P1 Payload Data Format

offset	Name	Data Type	Description
0	Param1	float	Retrieved Parameter (Input data can be ignored)
4	Param2	float	Reserved, default is 0
8	Param3	uint32	Index of the configured Parameter
12	Param4	uint32	Reserved, default is 0
16	Param5	Int32	Reserved, default is 0
20	Param6	Int32	Reserved, default is 0

Table 18 Serial Port P1 Payload Parameter Index Table

Param3	Param1	Unit
3	Serial output baud rate, supports the following baud rates 115200,230400,460800,921600,1500000	bps
4	Coordinate System Orientation (See Table 25Coordinate System Orientation Mapping Table)	
8	X-axis gyroscope Bias calibration result, GYRO_X_OFF	°/s
9	Y-axis gyroscope Bias calibration result, GYRO_Y_OFF	°/s
10	Z-axis gyroscope Bias calibration result, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, definition same as the SPI FILTER_CTRL lookup table	

Example: Get AHRS output frequency

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 31 2F A2 0A

According to response data, the parsed output frequency is 50 Hz (00 00 48 42).

7.1.6 Command Mode SET Command

Table 19 Serial Port Input Command Format

	Frame header	Frame header	ID	length	payload	Frame end
Data Type	uint8	uint8	uint16	uint16	R1	uint32
Encoding	0x55	0xAA	CMD	0x0018		crc32

Note 1: For the relationship between CMD and R1, refer to the Parameter Index Table for R1 Payload

Table 20 Serial Port R1 Payload Data Format

offset	Name	Data Type	Description
0	Param1	float	Configured Parameter
4	Param2	float	Reserved, default is 0
8	Param3	uint32	Index of Configured Parameter
12	Param4	uint32	Reserved, default is 0
16	Param5	Int32	Reserved, default is 0
20	Param6	Int32	Reserved, default is 0

Table 21 Serial Port R1 Payload Parameter Index Table

CMD	Param1	Param3	Description
1	0	0	Trigger to obtain 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, Disable Stream Mode, Enter COMMAND Mode
5	0	0	Save Current Parameter to FLASH
6	0	<value>	Read Parameter, value is the index of the Parameter to be read, i.e., P1.index, see Serial Port Response Output - Parameter Read For example, to read the AHRS output frequency (ODR), set value=21 For example, to read serial port baud rate, set value=3 For example, to read the internal filter, set value=31 For example, to read the coordinate system orientation, set value=4
9	0	0	Execute Software Restart

14	<value>	3	Set Serial output baud rate, unit bps. Valid values for value: 115200,230400,460800,921600,1500000 If value is other than the above, 115200bps is used by default. After setting the baud rate Parameter, a restart is required for it to take effect. Procedure without power cycle: Set baud rate, save Parameter to flash, execute software reset.
14	<value>	21	Set periodic AHRS data output frequency, unit Hz. Common values for value: 1, 10, 50, 100, 200, 500, 1000 Recommended correspondence between output frequency and serial port baud rate 1000Hz:921600bps 500Hz:460800bps 250Hz:460800bps 200Hz:460800bps 100Hz:115200bps
14	<value>	31	Internal filter configuration, defined same as SPI Accelerometer and Gyroscope filter configuration, default 0xBB, i.e., 47Hz
14	<value>	4	Set the IMU coordinate system orientation. The value range is 101~124. For specific coordinate system orientation mappings, refer to Table 2.5

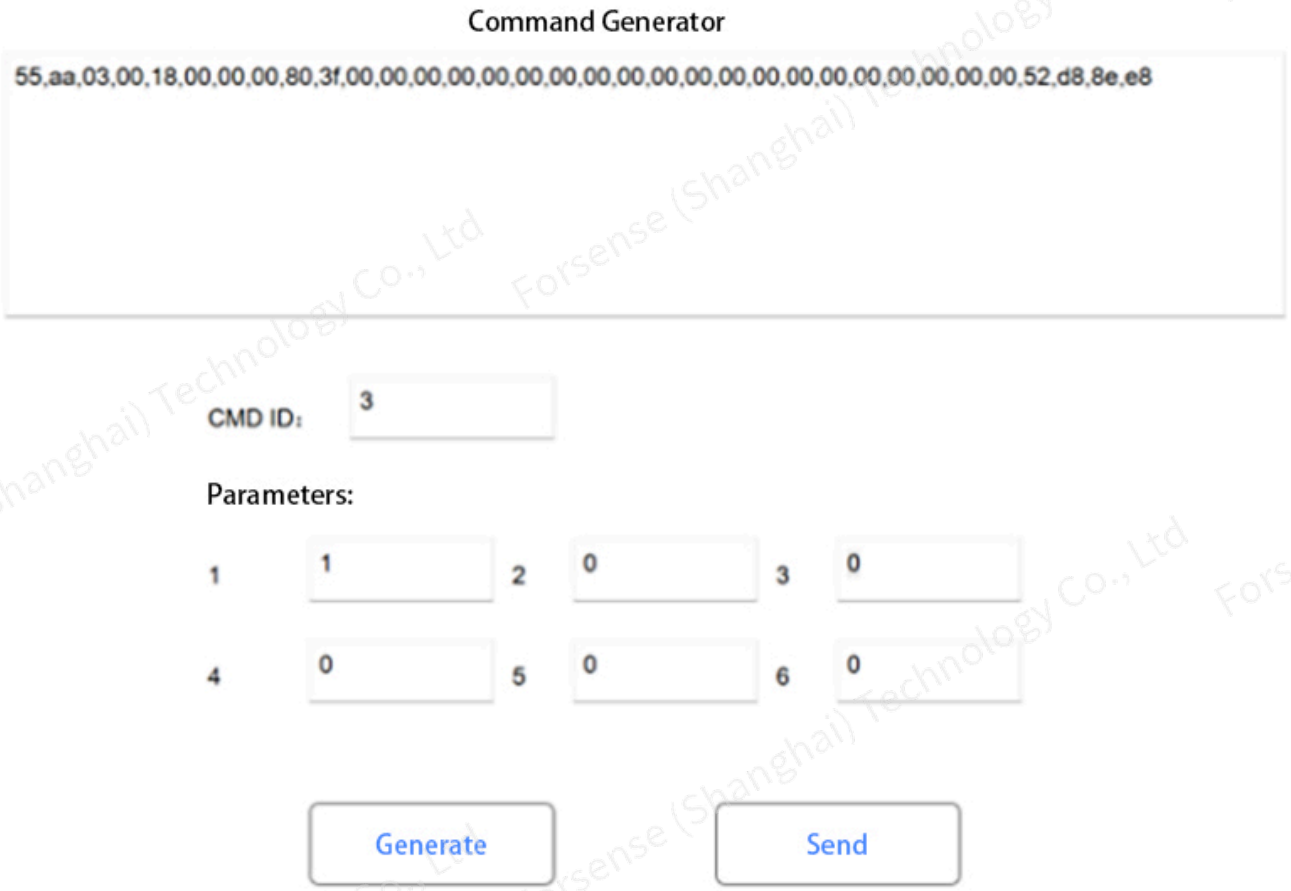
Note 1: Please note that all values in this table are in decimal.

Note 2: Use the PC software command generator function to generate and send the corresponding command.

For example, to enable AHRS output:

Enter 3 for CMD ID and 1 for Parameter 1. The generated hexadecimal array can be sent to the IMU via the Serial Port assistant or a program array.

Figure 8 Enable AHRS Output



7.1.7 Command Mode Output — User Command Response

Table 22 Set Parameter Serial Port response data Format

	Frame header	Frame header	ID	length	ACK	Param3	Frame end
Data Type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Encoding	0xAA	0x55	0x753D	0x0004	0x7534	Parameter Index	crc32

Table 23 Reserved Parameter Serial Port response data Format

	Frame header	Frame header	ID	length	ACK	result	Frame end
Data Type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Encoding	0xAA	0x55	0x753D	0x0004	0x0005	0x01	crc32

Table 24 Serial Port User Command response data Format

	Frame header	Frame header	ID	length	command	result	Frame end
Data Type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Encoding	0xAA	0x55	0x0064	0x0004	Command ID	0x01	crc32

Example: Set Serial output baud rate to 115200

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

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

Set periodic AHRS data output frequency to 100 Hz

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 0A 2B 2C 8D

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

Save Current Parameter 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 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 00 52 D8 8E E8

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

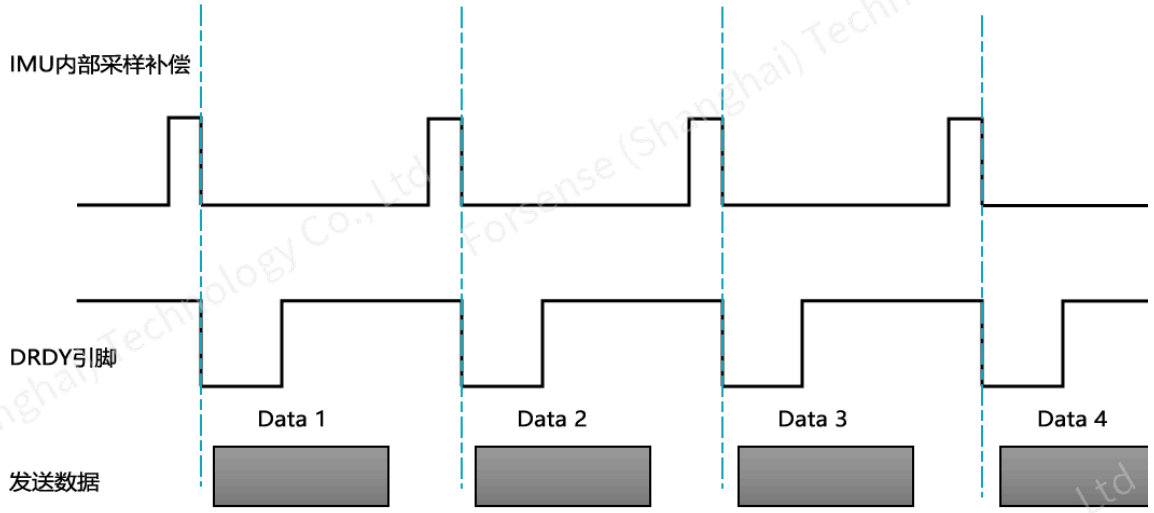
7.1.8 DRDY

The DRDY Pin output serves two purposes:

1. Provides clock synchronization signals from the internal IMU;

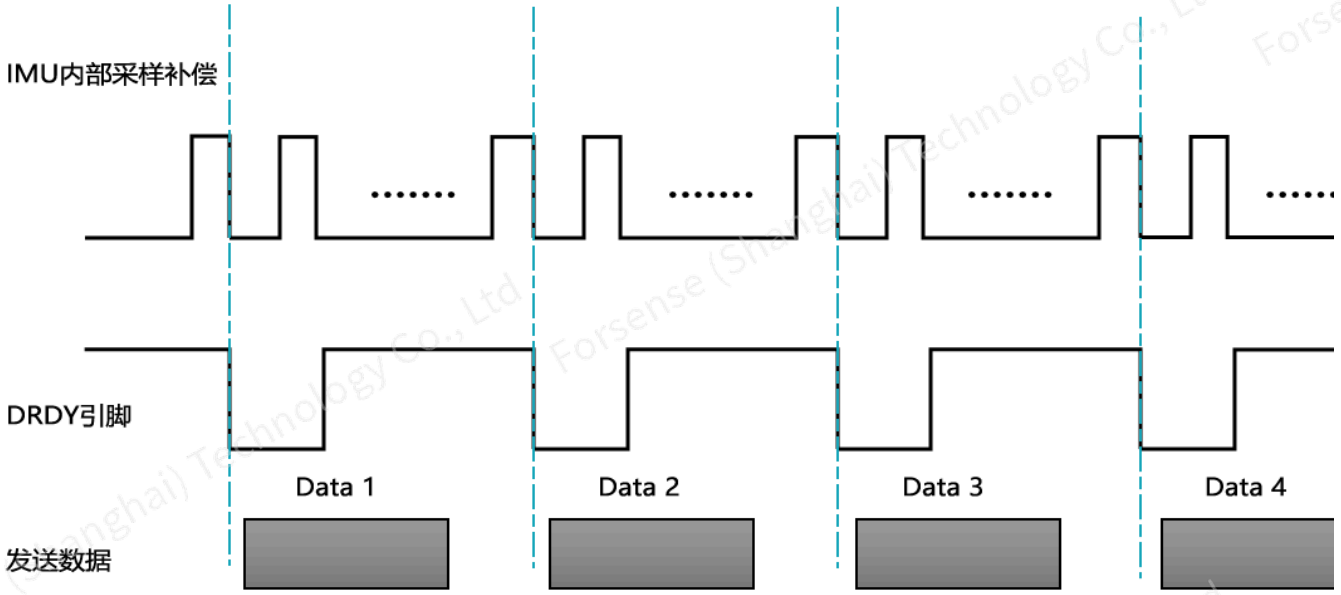
2. Provides a signal indicating the start of data frame transmission.

Figure9internal sampling frequency is consistent with serial output rate



When the IMU internal sampling frequency (maximum ODR) matches serial output rate (current ODR), DRDY Pin is immediately pulled low after each IMU data sampling compensation is completed, at which point the data frame is sent from Serial Port, and DRDY Pin is pulled high again in the next cycle.

Figure10serial output rate is less than IMU internal sampling frequency

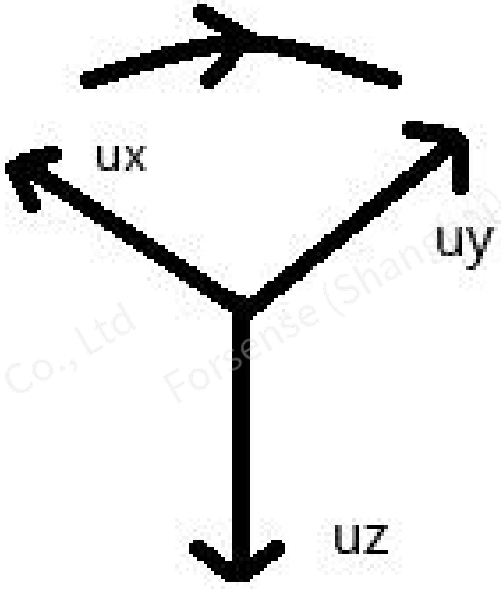


When serial output rate is less than the IMU internal sampling frequency, after each IMU data sampling compensation is completed, determine whether to immediately pull DRDY Pin low based on fractional frequency value (Max ODR / Current ODR). After DRDY is pulled low, the data frame will be sent from Serial Port, and DRDY Pin will be pulled high again in the next IMU sampling cycle.

7.1.9 Coordinate System Configuration

Set the firmware coordinate system; display the corresponding firmware design coordinate system in PC software

Figure11 Firmware Raw Coordinate System



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

There are a total of twenty-four possible orientations for the X/Y/Z axes, as shown in the table below:

Table 25 Coordinate System Orientation Correspondence Table

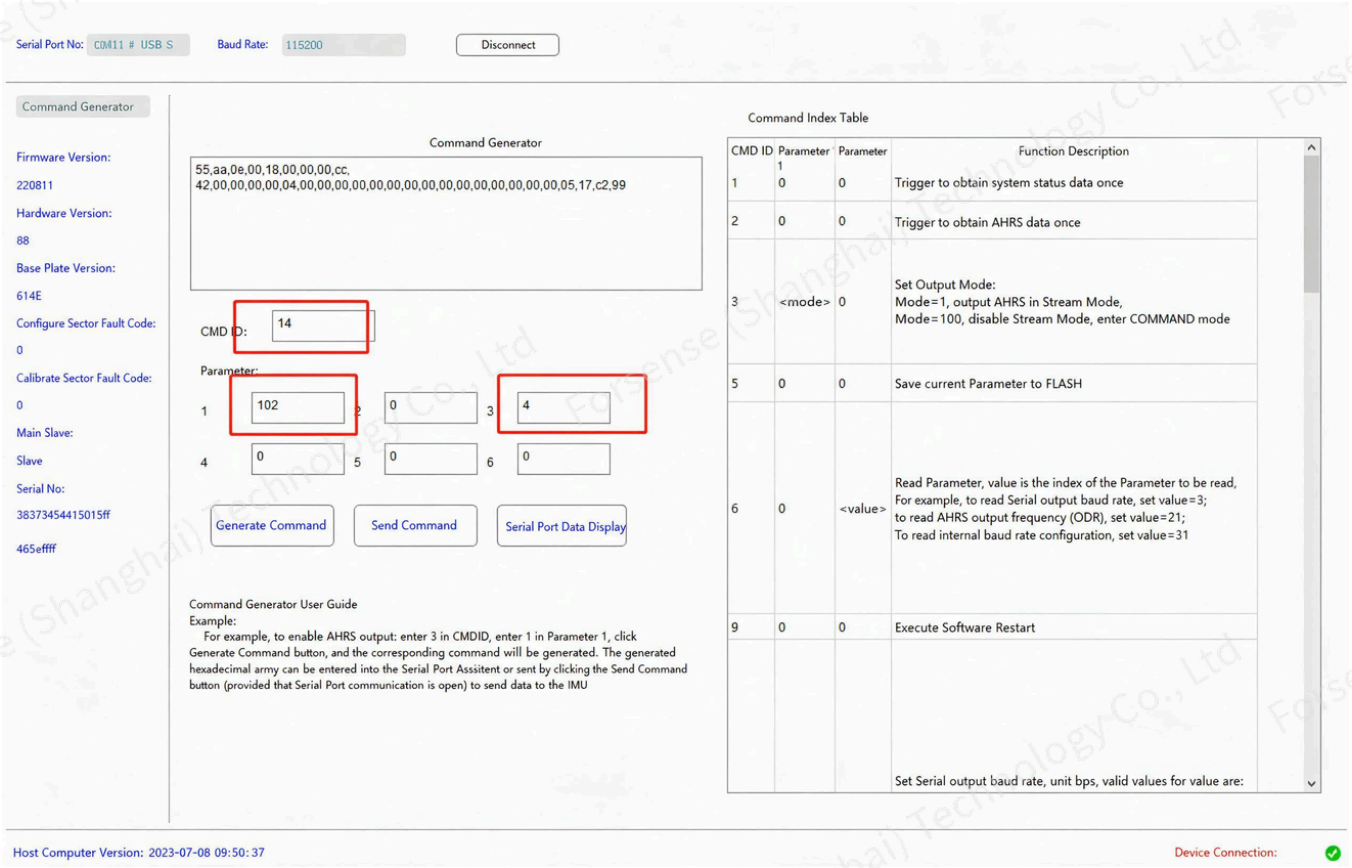
Orientation (Value)	XAxis	YAXis	ZAxis	Description
101	+Ux	+Uy	+Uz	Default Orientation
102	-Ux	-Uy	+Uz	
103	-Uy	+Ux	+Uz	
104	+Uy	-Ux	+Uz	
105	-Ux	+Uy	-Uz	
106	+Ux	-Uy	-Uz	
107	+Uy	+Ux	-Uz	
108	-Uy	-Ux	-Uz	
109	-Uz	+Uy	+Ux	
110	+Uz	-Uy	+Ux	

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 Orientation 102:

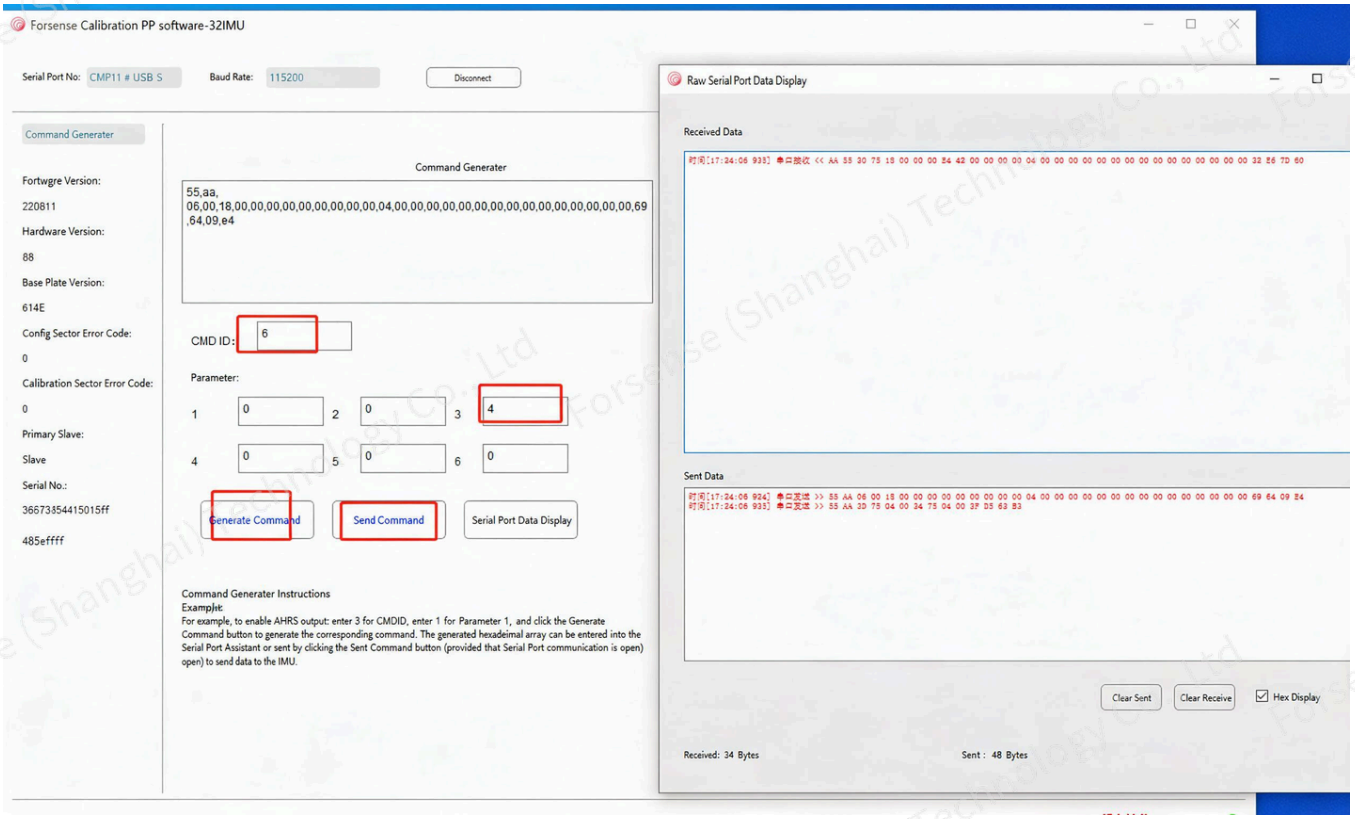
Enter 14 for CMD ID, enter 102 for Parameter 1, and enter 4 for Parameter 3. The generated hexadecimal array can be entered into the Serial Port Assistant or program array and sent to the IMU.

Figure 12 Change the coordinate system to orientation 102



How to Read the Coordinate System Orientation:

Enter 06 for CMD ID, enter 4 for Parameter 3, and the generated hexadecimal array can be entered into the Serial Port assistant or program array to send to the IMU. Figure 13 Read Coordinate System Orientation



Example: Set the coordinate system to orientation 115

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

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

Refer to Table 22The parsed Parameter index is 04, and the setting was successful

Read 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 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 Table 16and the table17, parsing yields Parameter 1 as 115 (float) and Parameter 3 as 04. Thus, the coordinate system orientation is 115.

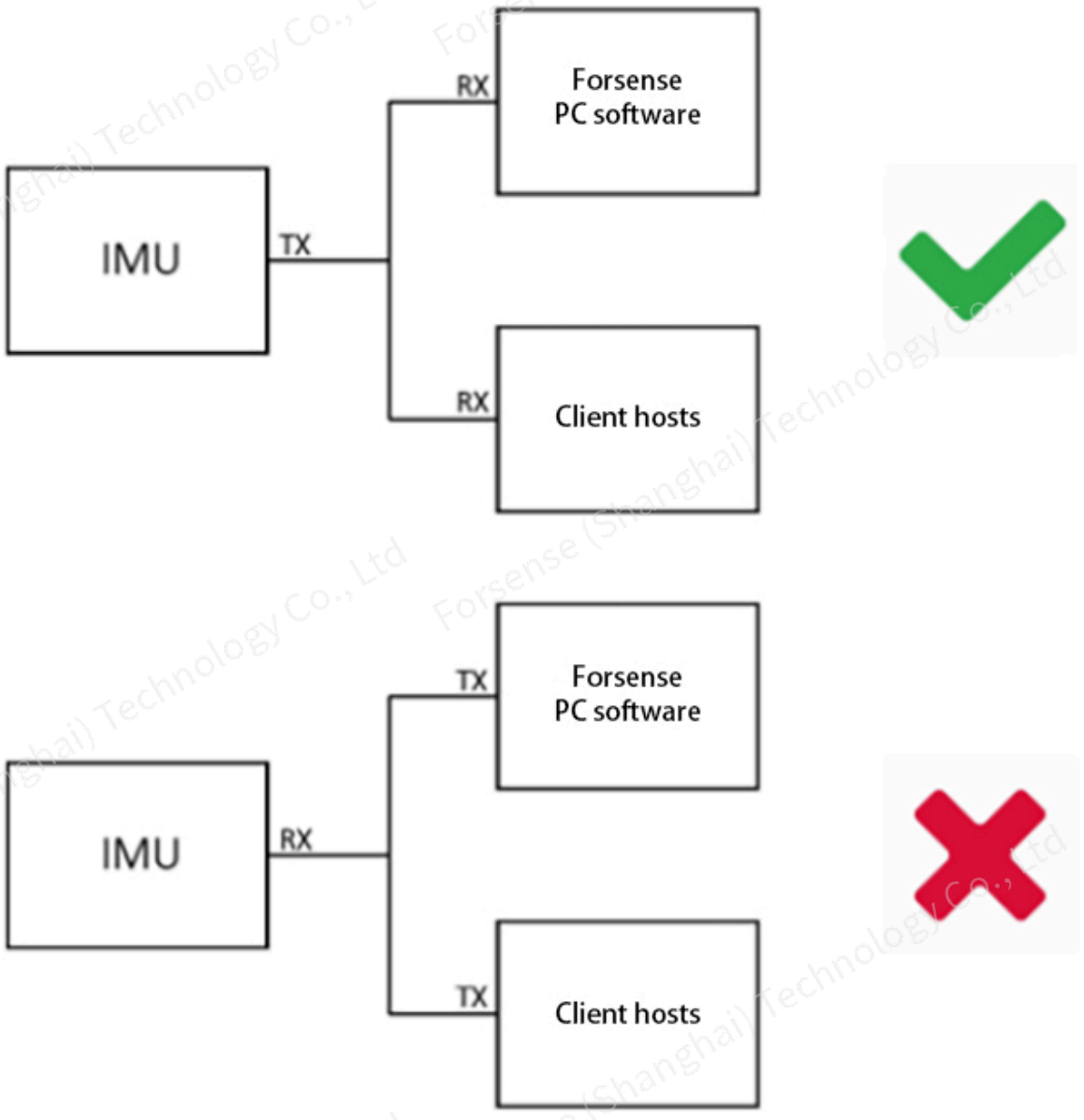
7.1.10 Serial Port Connect FAQs

(1) The IMU RX cannot be connected to 2 Master TX

The RX of Serial Port cannot be connected to 2 TXs simultaneously. Therefore, when connecting Forsense PC software, you must disconnect its serial communication from the user's Master; otherwise, PC software can only receive data and cannot send commands to the IMU.

As shown in the figure below:

Figure14Serial Port Connection Diagram



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

2) Unable to obtain version number

Check if the Serial Port cable is packet loss. It is recommended to use a Serial Port cable with a FT232 chip. Data cables with CH340 or PL2303 chips may packet loss at high baud rates (>115200bps).

It is recommended to connect the Serial Port cable directly; daisy-chaining is not recommended. For example, when connecting the interface of RS422 to a PC, use a RS422 to USB cable directly. Do not daisy-chain a RS422 to RS232 adapter with a RS232Z to USB adapter.

3) Lag in PC software curve display

If using a FT232 data cable, open PC software as Administrator to automatically configure the Serial Port latency.

Manually configure the Serial Port latency in Device Manager.

7.2 I2C Communication Protocol

Example driver for reading Master based on STM32 and I2C:

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

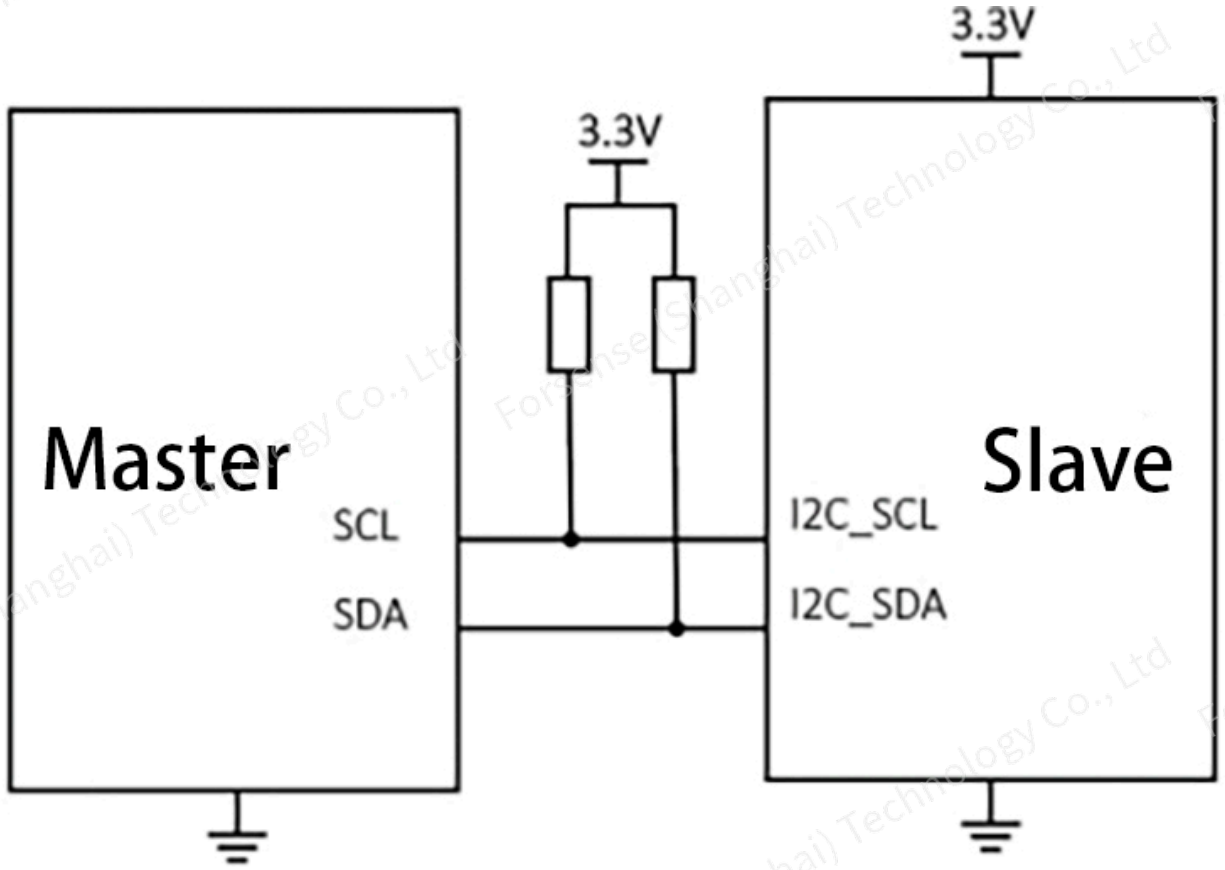
7.2.1 I2C Interface Parameter

Table 26I2C Interface Parameter

I2C Rate	400KHz
I2C Slave Address (7-bit)	0x18

7.2.2 I2C Connection Method

Figure15 I2C Connection Method



Note: pull-up resistor value is 4.7KΩ

7.2.3 I2C Register

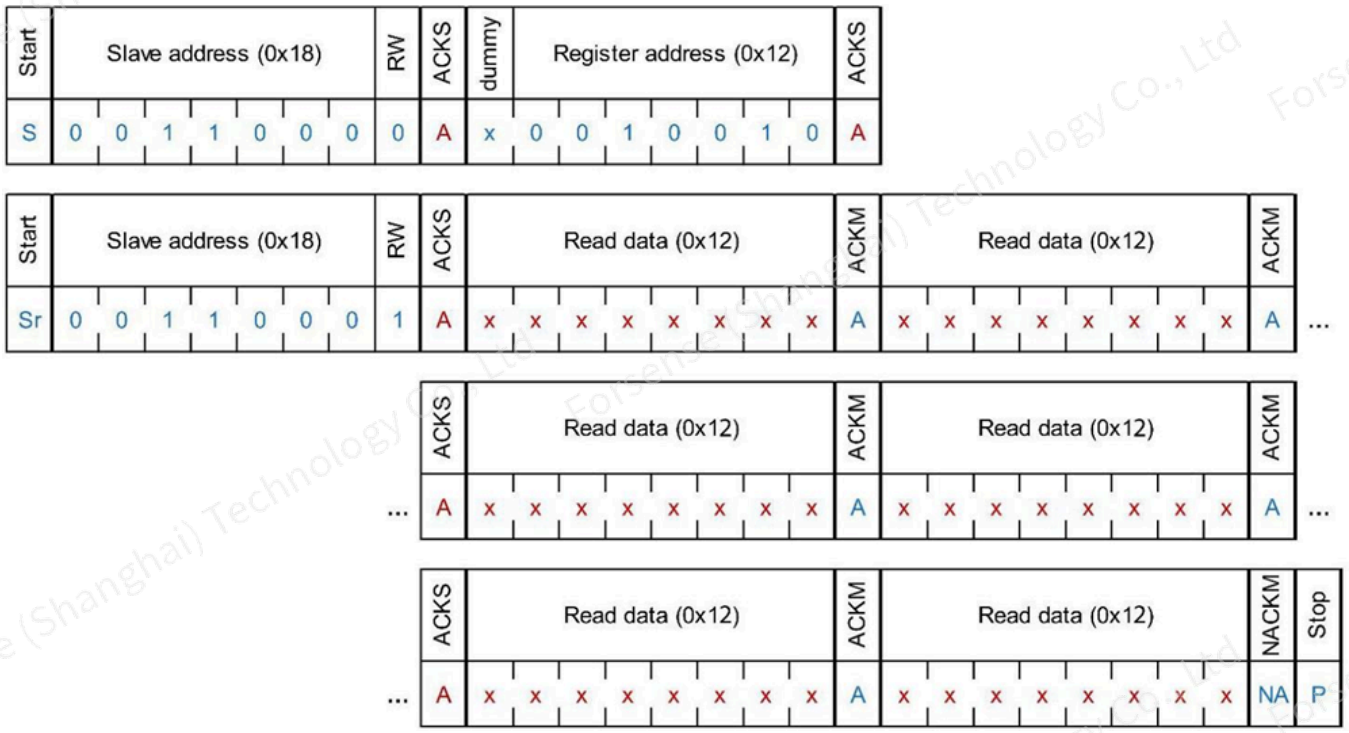
Table 27 I2C Register List

Name	Address	Read/Write	Default Value	Description
BURST	0x12	R		Continuous Read Register
FILTER_CTRL	0x06	RW	0xBB	Filter Selection
PROD_ID	0x6A	R		Product Name

7.2.3.1 I2C BURST Register

This I2C protocol supports continuous reading. When continuously reading from Register address 0x12, the Slave automatically increments the address and outputs data in 8-bit mode.48bytes. The read process is as follows:

Figure 16 I2C Continuous Read Mode



The frame is defined as follows:

Table 28 I2C Continuous Read Data Format

Transmission Order	**1**	**2**	**3**
Data Format	uint32_t	float	float
Transmission Content	TIME	ACCL_X	ACCL_Y
Transmission Order	4	5	6
Data Format	float	float	float
Transmission Content	ACCL_Z	GYRO_X	GYRO_Y
Transmission Order	7	8	9
Data Format	float	float	float
Transmitted Content	GYRO_Z	TEMP	ROLL
Transmission Order	10	11	12
Data Format	float	float	uint32

Transmitted Content	PITCH	YAW	CRC32

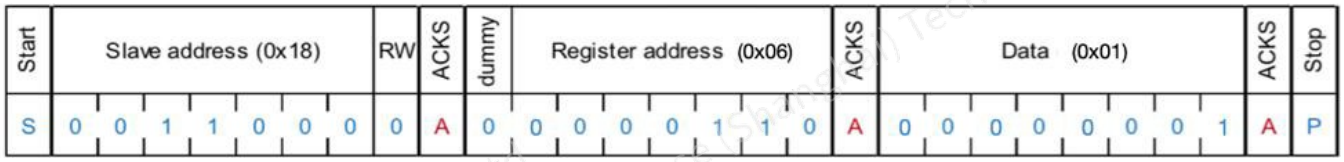
Note 1: The unit of TEMP is °C, and the output unit of Gyroscope is °/s, the output unit of Accelerometer is g, and the attitude output unit is degrees

Note 2: The initial value of crc32 is 1. CRC calculation excludes the current frame data itself. See Appendix 1 for the lookup table method.

7.2.3.2 I2C FILTER_CTRL Register

The address of FILTER_CTRL Register is 0x06. The filter configuration lookup table is the same as that for SPI Accelerometer and Gyroscope.filter configuration. The Register read process is the same as the I2C BURST read method. The write Register process is shown in the figure below.

Figure 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 ASCII-encoded string "IMU61B". The read process is the same as I2C BURST, as shown in the table below.

Table 29 I2C ID Register Read Mode

Transmission Order	**1**	**2**	**3**	**4**
Transmitted Content	0x00	0x00	0x49	0x4D
Transmission Order	5	6	7	8
Transmitted Content	0x55	0x36	0x31	0x*

Note 1: All data are 8-bit wide

Note 2: The content represented by 0x* is the Product ID. 0x32 represents IMU612, 0x34 represents IMU614, 0x38 represents IMU618, 0x41 represents IMU6132A, and 0x42 represents IMU6132B.

7.3 SPI Communication Protocol

Example of SPI Master Read Driver Based on STM32:

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

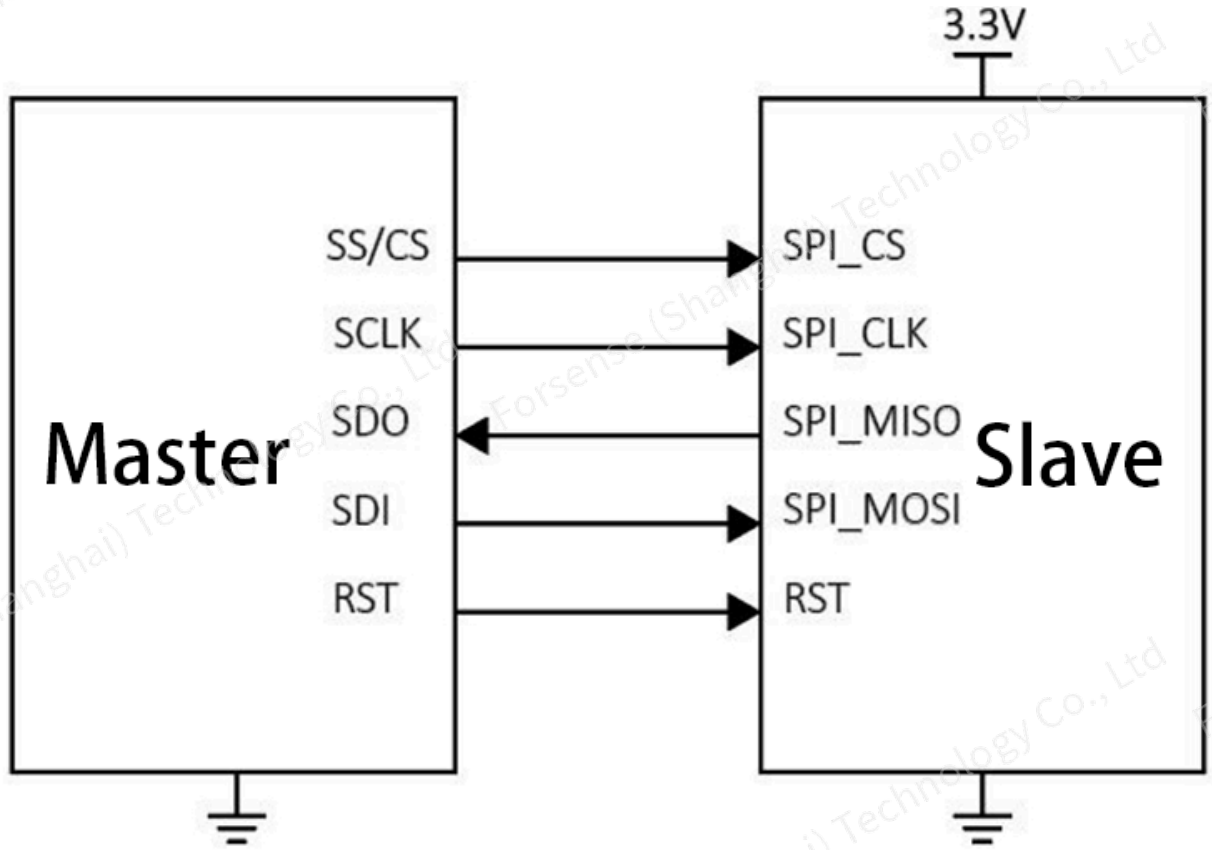
7.3.1 SPI Interface Parameter

Table30SPI Interface Parameter

SPI Master	This product serves as Slave
SPI Rate	0.2~2MHz
SPI Word Length	16bit
Phase	Rising Edge Trigger (Mode 3, CPHA=1)
Polarity	Idle High power level (Mode 3, CPOL=1)
bit sequence	MSB First

7.3.2 SPI Connection Diagram

Figure18 SPI Wiring Diagram



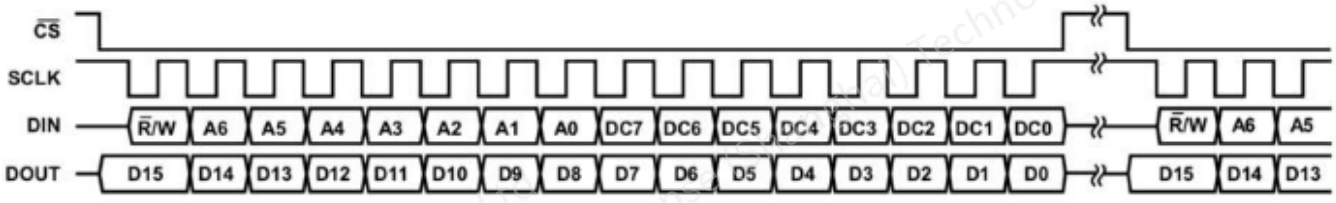
Note 1: Before initialize read, reset the IMU and wait for 3 s to allow it to enter normal operating state.

Note 2: For SPI Pin of different IMU models, refer to the corresponding manual

7.3.3 SPI Communication bit sequence

The SPI interface supports full-duplex serial communication (simultaneous transmit and receive), using the bit sequence shown in the figure below.

Figure 19 SPI Communication bit sequence Schematic



Here, the MSB of DIN indicates Read/write operation, [A6:A0] represents the Register address, and [DC7:DC0] represents the data to be written (write operation) or DUMMY data (read operation).

When /W = 1, the DOUT data for this SPI cycle is meaningless. When /W = 0, the DOUT data for this SPI cycle represents the output data from the previous two cycles of Register; see the BURST read example for details.

7.3.4 SPI Register

Table31 SPI Register List

Name	Address	Read/Write	Default Value	Window ID	Description
BURST	0x00	RW		0	Continuous Read
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	Accelerometer X-axis High Byte

XACCEL_LOW	0x20	R	\	0	Accelerometer X-axis Low Byte
YACCEL_HIGH	0x22	R	\	0	Accelerometer Y-axis High Byte
YACCEL_LOW	0x24	R	\	0	Accelerometer Y-axis Low Byte
ZACCEL_HIGH	0x26	R	\	0	Accelerometer Z-axis High Byte
ZACCEL_LOW	0x28	R	\	0	Accelerometer Z-axis Low Byte

7.3.4.1 SPI BURST Register

BURST reads Register continuously, retrieving all data in a single stream with no gaps between the 16-bit segments.

Table 32 SPI BURST Register Format

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

The BURST read method is as follows: Send 0x8000 before reading to set BURST and start the read operation, then continuously send 0x0000 and receive data. The output Register content lags behind the read command offset by 2 SPI cycles. Keep chip select low at power level throughout the read period.

Figure20SPI Burst Continuous Read Diagram

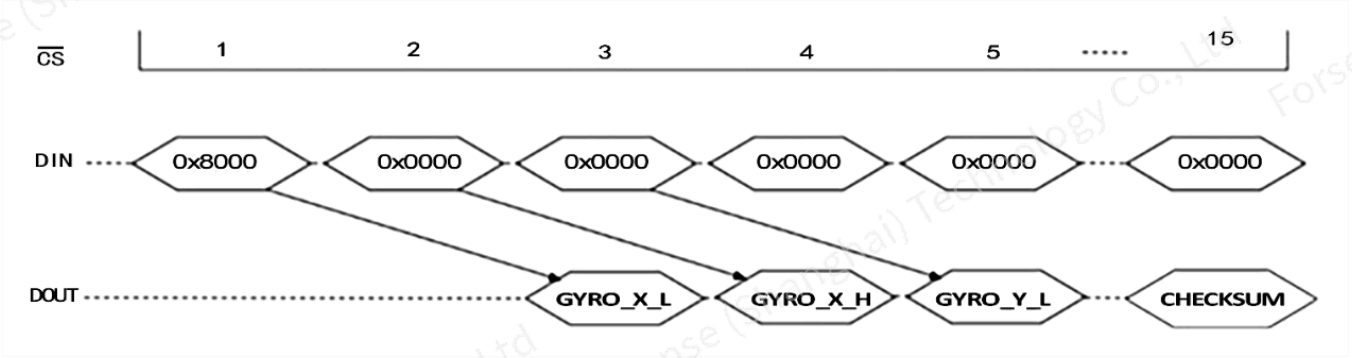


Table 33 Basic Format of SPI BURST Continuous Read

Transmission Order	**1**	**2**	**3**	**4**	**5**	**6**
Transmission Content	GYRO_X_L	GYRO_X_H	GYRO_Y_L	GYRO_Y_H	GYRO_Z_L	GYRO_Z_H
Transmission Order	7	8	9	10	11	12
Transmission Content	ACCL_X_L	ACCL_X_H	ACCL_Y_L	ACCL_Y_H	ACCL_Z_L	ACCL_Z_H
Transmission Order	13					
Transmission Content	CHKSM					

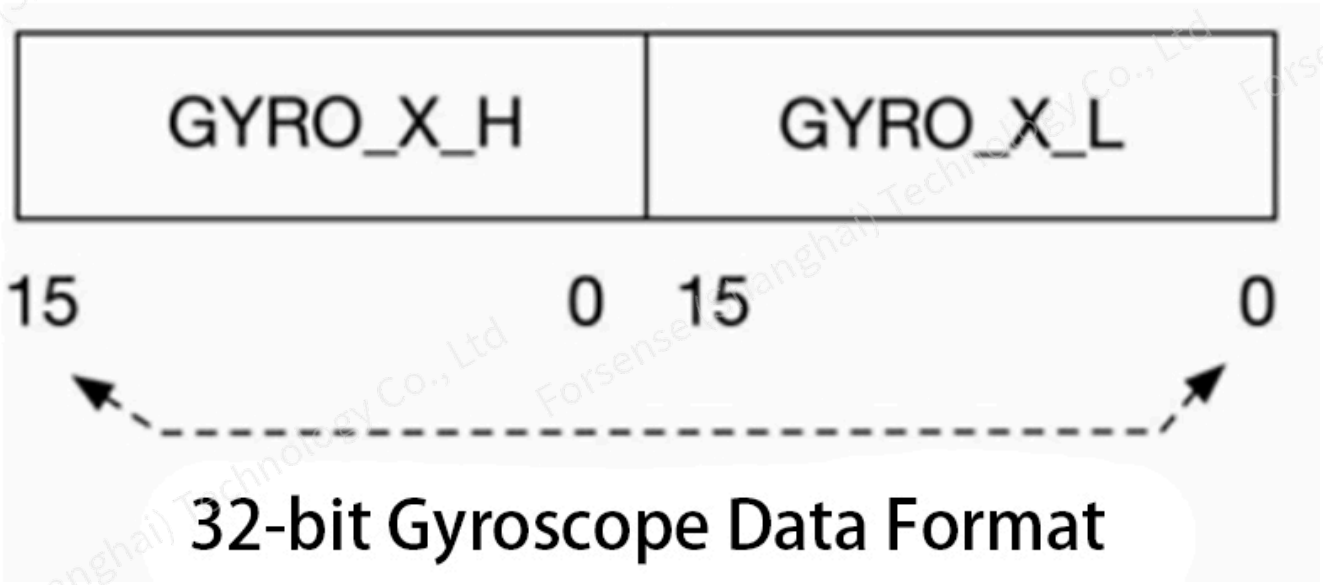
Note 1: All data are 16-bit wide

Note 2: The concatenated format of gyroscope and Accelerometer data is represented as int32

Note 3: CHKSM is CHECKSUM, used to verify data integrity. It is calculated by summing all data preceding the CHECKSUM.

During BURST continuous read, the full 32-bit data is split into the upper 16 bits and lower 16 bits for separate output. The output uses little-endian mode, i.e., least significant byte first. Users need to concatenate these two 16-bit parts in order to reconstruct the complete 32-bit data.

Figure21SPI32-bit Data Restoration Diagram



After obtaining the complete 32-bit data, standard frame users can convert it into Angular velocity, acceleration, temperature, and attitude angle information using the following formula.

Table 34 Standard Frame SPI 32-bit Data Conversion Formula

Name	Unit	Formula	Condition/Note
Angular velocity	°/s	G=SF/65536*GYRO	GYRO refers to the GYRO data for the X/Y/Z axes in the table above • Gyroscope scale factorSF = 0.016
Acceleration	mg	A=SF/65536*ACCL	ACCL is the ACCL data for the X/Y/Z axes in the table above • In Burst mode,SF= 0.2 • In single Register mode, SF=0.2/1000
Temperature	℃	T=SF/65536*TEMP-172621824+25	TEMP is the TEMP data in the table above • Temperature scale factorSF =-1/263.4
Attitude Angles	°	D=SF/65536*ATT	ATT is the ATT data in the table above • Attitude scale factorSF = 0.00699411

7.3.4.2 SPI FILTER_CTRL Register

Register FILTER_CTRL provides users with control over the digital low-pass filter. This Register is a read/write Register. The write command sends 0x86XX, and the current SPI cycle setting takes effect; the read command sends 0x0600, and the output Register content lags behind the read instruction by 2 SPI cycles.

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

	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 gyroscope and Accelerometer filter are configured to 10Hz, write the value 0x8644.

7.3.4.3 SPI ID Register

ID Register is a read-only Register, and its data content is the ASCII-encoded string "IMU". The reading method is similar to BURST data reading: send 0x6C00~0x7000 and receive the data. The output Register content lags behind the read instruction by 2 cycles.

Concatenate the 4 16-bit ID data and convert them to ASCII code to obtain the complete product ID. The concatenation method is the same as that for BURST continuous read data, with PROD_ ID1 in the high byte and PROD_ ID4 in the low byte.

Table 37 SPI ID Register Format

Address	bit15 ~ bit0	Encoding	Read/Write
0x6C	PROD_ID1	0x494D	R
0X6E	PROD_ID2	0x5536	R
0x70	PROD_ID3 The encoded value 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 the Window ID. It supports both read and write operations. The default window is 0; writing 0xFE01 switches it to 1.

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	Encoding	Description
WINDOW_ID	0x00	window0, Start Reading Data
	0x01	window1, Enter Configuration

7.4 Common AT Commands

7.4.1 Stop Current Data Stream Output

Command : AT+SETNO\r\n

Response: OK

You can stop the current data stream (without changing the data stream Parameter). Outputting OK indicates that the next operation can proceed.

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

Enable Data Stream Output

Command: AT+SETYES\r\n

7.4.2 Query Version Number

Command: AT+VERSION\r\n

Response: SW_VERSION Firmware Version HW_VERSION Hardware Version BOARD_VERSION Base Plate Version

OK

7.4.3 Query User Parameter

Command: AT+CONFIG Response: BAUD_RATE Current serial port baud rate ORIENT Current Coordinate System IMU_ODR Current IMU Output Rate STREAM_ MODE1 Current Serial Port 1 Stream Mode STREAM_ MODE2 Current Serial Port 2 Stream Mode STREAM_ MODE3 Current Serial Port 3 Stream Mode LP_CONFIG_REG Current IMU Filter

OK

7.4.4 Set and Query ODR

Example: Set the Output Data Rate (ODR) to 50Hz Command: AT+SET_ODR=50\r\n Response: IMU_ODR:50

OK Query IMU ODRCommand: AT+GET_ODR\r\n Response: IMU_ODR:50

OK

7.4.5 Set and Query Coordinate System

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

Command: AT+SET_ORIENT=101\r\n

Response: orientation:101

OK

Query Current IMU Coordinate System

Command: AT+GET_ORIENT\r\nResponse: orientation:101

OK

7.4.6 Set and Query Baud Rate

Example: Set the IMU baud rate to 115200

Command: AT+SET_BAUD=115200\r\nResponse: OK

Query Current IMU Baud Rate

Command: AT+GET_BAUD\r\n

Response: BAUD_RATE=115200

OK

7.4.7 Set Roll and Pitch Inversion

AT+SET_ATT_ORIENTATION=00\r\n No inversion for roll and pitch

AT+SET_ATT_ORIENTATION=01\r\n Invert roll, no inversion for pitch

AT+SET_ATT_ORIENTATION=10\r\n No inversion for roll, invert pitch

AT+SET_ATT_ORIENTATION=11\r\n Invert both roll and pitch

7.4.8 Set and Query Filter

Example: Set IMU filter to 20Hz

Command: AT+SET_LPF=102\r\n

Response: LP_CONFIG_REG:102

OK

Query Current IMU Filter

Command: AT+GET_LPF\r\n

Response: LP_CONFIG_REG:102

OK

Table40 Low-Pass Filter Values and Corresponding AT Command Values

No.	IMU Low-Pass Filter Value	Value Corresponding to 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 (No Filtering)	187

7.4.9 Save Parameter

Command: AT+SAVE Response: OK

7.5 CAN Communication Protocol

Example of CAN Master Read Driver Based on STM32:

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

7.5.1 Communication Parameter

Interface Type: CAN, Standard Frame

CAN Baud Rate: 250 Kbps to 1 Mbps (Configurable)

7.5.2 Standard Frame Format

Table 41CAN Standard Frame Format 101

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

Table 42CAN Standard Frame Format 102

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

Table 43 CAN Standard Frame Format 103

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

Table 44 CAN Standard Frame Format 104

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

Table 45 CAN Standard Frame Format 105

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

Note 1: Attitude angles, gyroscope, and Accelerometer data are represented as float; temperature and count value data are represented as int16

Note 2: The unit of TEMP is 100*°C, the output unit of Gyroscope is °/s, the output unit of Accelerometer is g, and the attitude output unit is degrees

7.5.3 CAN Parameter Configuration

7.5.3.1 Configure CAN Baud Rate

Configure CAN Baud Rate, Send Command:

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

IMU Response:

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

Query CAN Baud Rate, Send Command:

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

IMU Response:

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

Where:

XX=01 Baud Rate is 250 Kbps

XX=02 Baud Rate is 500 Kbps

XX=03 Baud Rate is 1000 Kbps

7.5.3.2 Configure Node ID

The default node is 100. Set the Node ID to 0X0102., send command:

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

The IMU responds as follows:

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

7.5.3.3 Query Version Number

Send Command:

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

The IMU responds as follows:

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

Version number is: 0X0003120E, i.e., Firmware Version No.: 201230

7.5.3.4 Query/Set Terminal Resistor

Remove the terminal resistor and send the command:

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

The IMU responds as follows:

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

Add Terminal Resistor, Send Command:

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

IMU Response:

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

7.5.3.5 Set Output Frequency

Set Output Frequency, Send Command:

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

IMU Response:

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

Query Output Frequency, Send Command:

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

IMU Response:

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

Where:

XX=01 Output Frequency is 1HZ

XX=02 Output Frequency is 10HZ

XX=03 Output Frequency is 50HZ

XX=04 Output Frequency is 100HZ

XX=05 Output Frequency is 200HZ

7.5.3.6 Query/Set Roll and Pitch Inversion

To set roll and pitch inversion, send the command:

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

IMU Response:

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

To query the inversion status of Roll and Pitch, send the command:

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

The IMU responds as follows:

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

Where:

XXXX=0X00 Neither Roll angle nor Pitch angle is inverted

XXXX=0X01 Neither Roll angle nor Pitch angle is inverted

XXXX=0X10 Roll angle is not inverted, Pitch angle is inverted

XXXX=0X11 Roll angle is not inverted, Pitch angle is inverted

7.5.3.7 Query/Set Filter Cutoff Frequency

Set Filter Cutoff Frequency, send command:

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

The IMU responds as follows:

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

Query the status of Filter Cutoff Frequency, send command:

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

The IMU responds as follows:

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

Where:

XXXX=0X44 cutoff frequency 10HZ

XXXX=0X66 cutoff frequency 20HZ

XXXX=0XAA cutoff frequency 40HZ

XXXX=0XBB cutoff frequency 47HZ

7.5.3.8 Query/Set Coordinate System

Set Coordinate System, Send Command:

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

IMU Response:

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

Query Orientation Setting, Send Command:

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

IMU Response:

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

Where:

XXXX=0X65 Default Orientation

CAN is configured in hexadecimal, while Chapter 7 displays decimal values. For specific orientation settings, refer to Chapter 8 of the manual.

7.5.3.9 Disable/Deduct Attitude Angles

To disable or enable attitude angle deduction, send the command:

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

IMU Response:

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

To query the attitude angle deduction setting, send the command:

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

IMU Response:

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

Where:

XXXX=0X01 Deduct Attitude Angles

XXXX=0X00 Neither Roll angle nor Pitch angle is inverted

7.5.3.10 Save Command

Send Command:

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

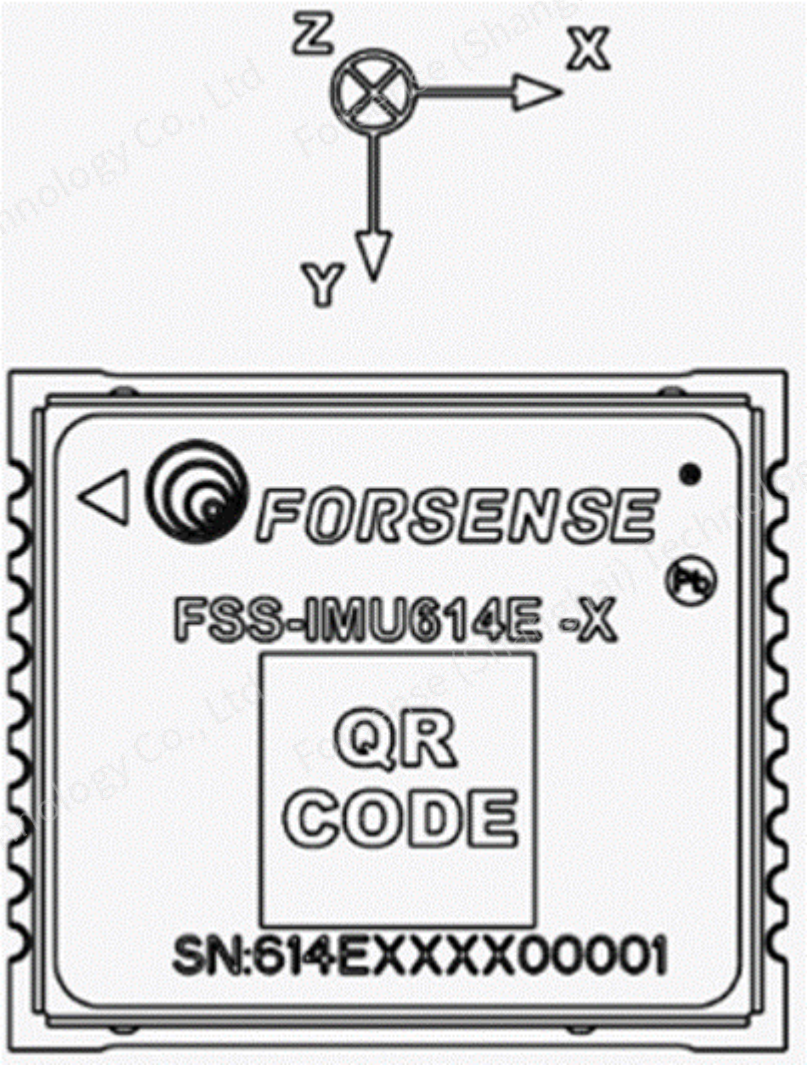
IMU Response:

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

Saving takes time. The response message is returned only after a successful save. Changes take effect after rebooting.

8. Coordinate System Definition

Figure 22 Coordinate System Definition



This product uses the Front-Right-Down (FRD) coordinate system. The Euler angle ranges are as follows:

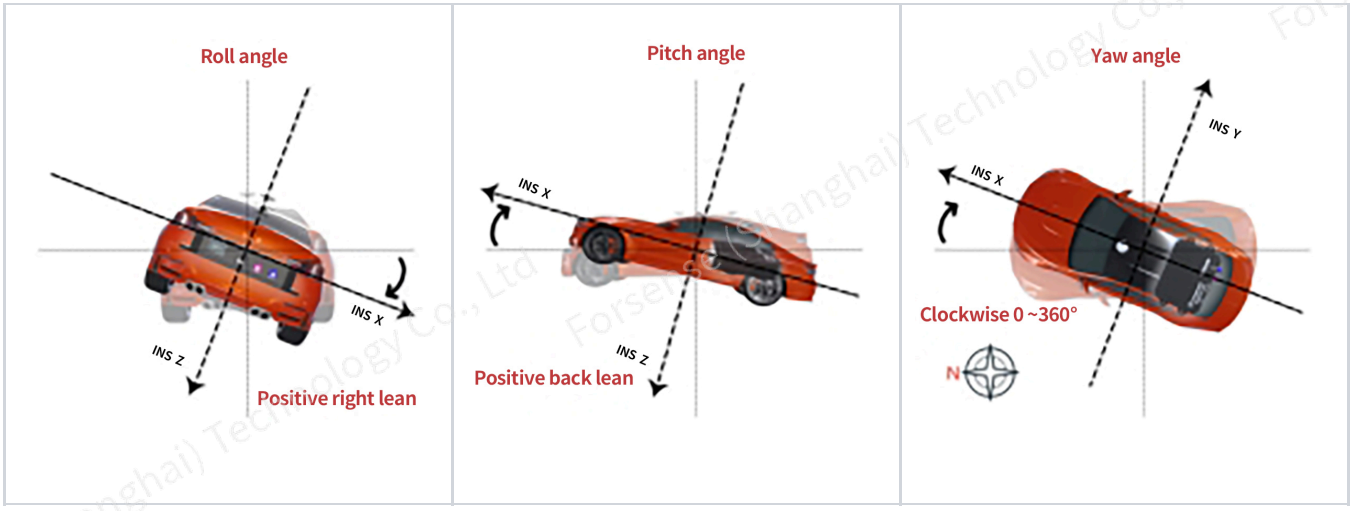
Rotation around the Z-axis: Yaw angle Yaw range: 0° ~ 360°

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

Rotation around the Y-axis: Pitch angle Pitch range: -90° ~ 90°

The diagram below illustrates Roll, Pitch, and Yaw angle angles:

Figure 23 Schematic of Roll, Pitch, and Yaw angle



9. CRC Calculation Using Lookup Table

It is recommended to refer directly to the sample code.

Note 1: Data is transmitted in little-endian format, with the low byte first and the high byte last.

Note 2: The initial value of crc32 is 1. CRC calculation excludes this field itself but includes all other data in the current frame.

```
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;
}
```

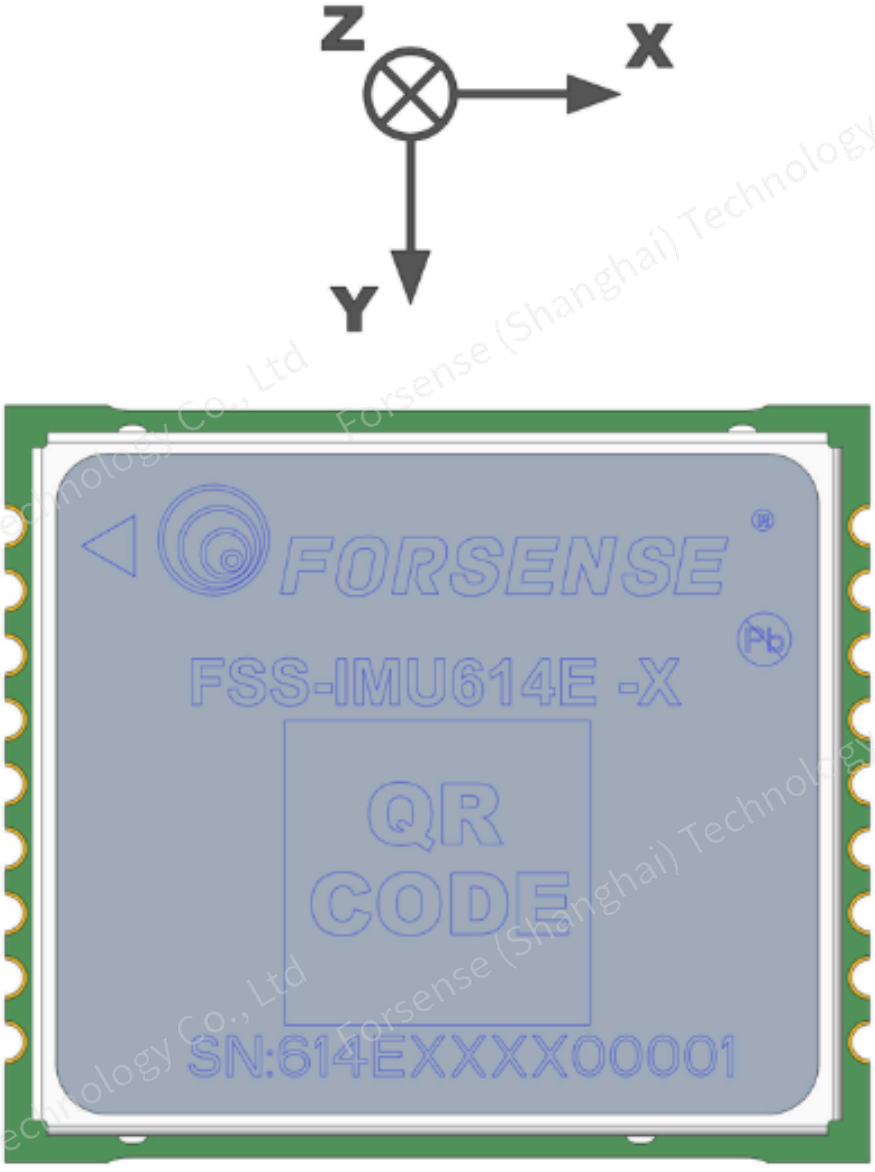
10. Usage Example

10.1 Device Installation

(1) The module should be securely fixed on a rigid plane, avoiding installation in locations with significant vibration.

(2) The orientation of the installed module should align with the direction of the vehicle's front.

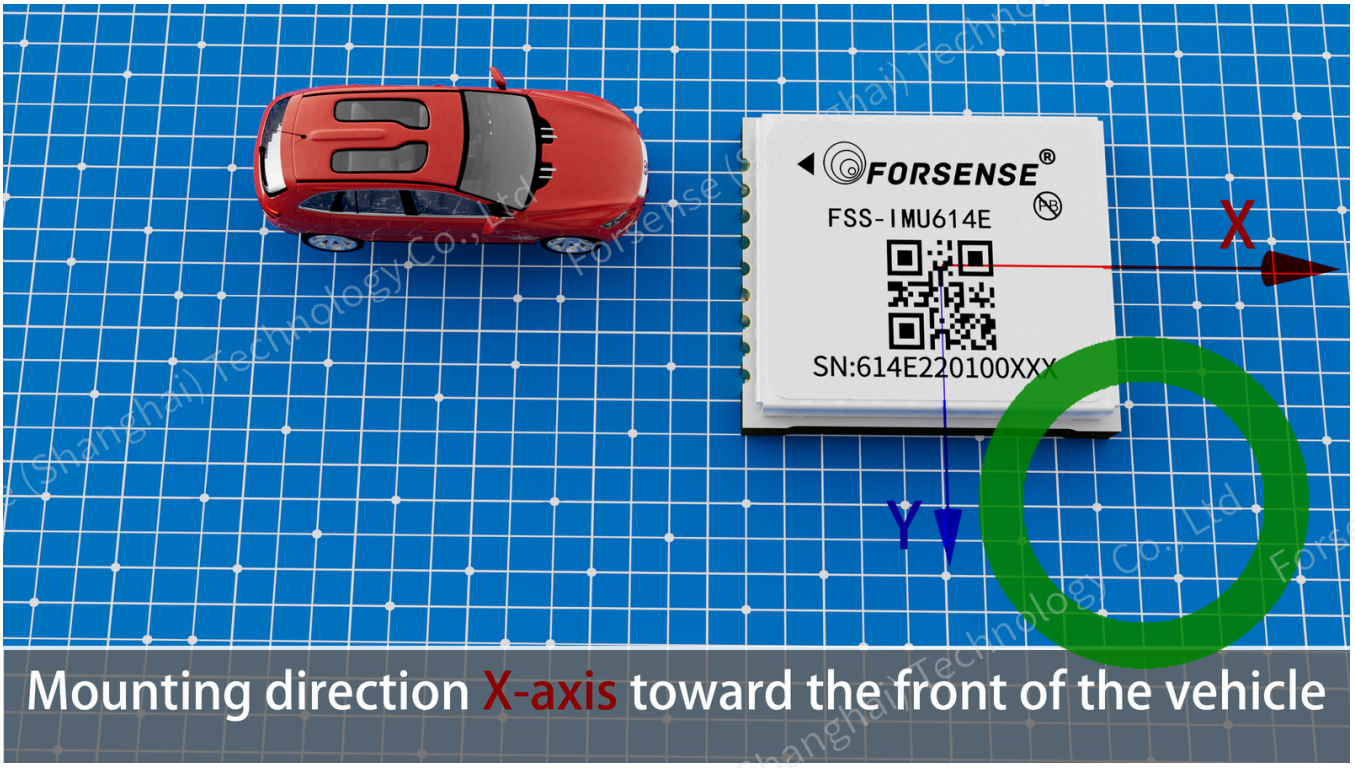
Figure24 Module Installation Diagram



The correct installation diagram is shown below

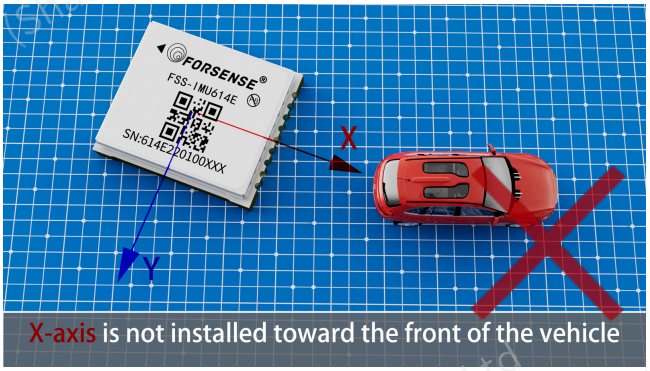
X-axis points toward the front of the vehicle

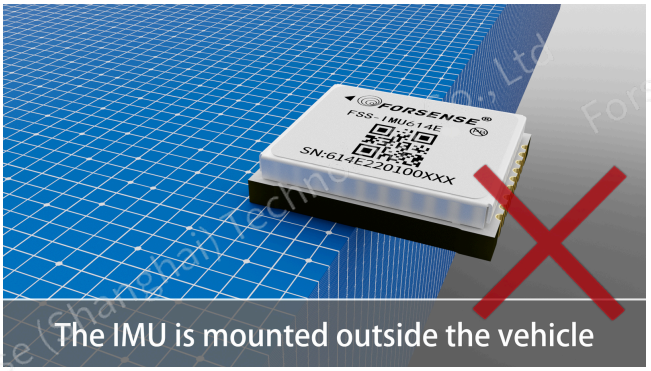
Figure 25 Correct Installation Diagram

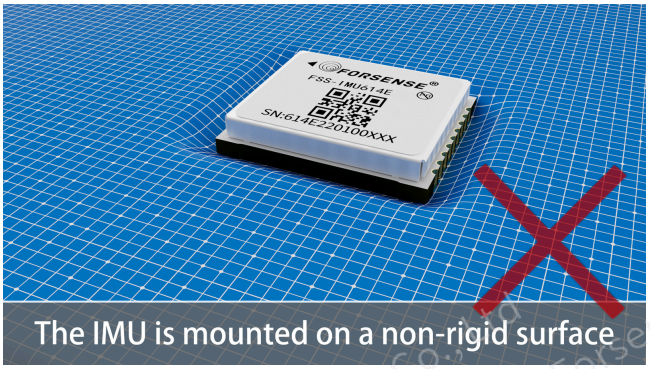


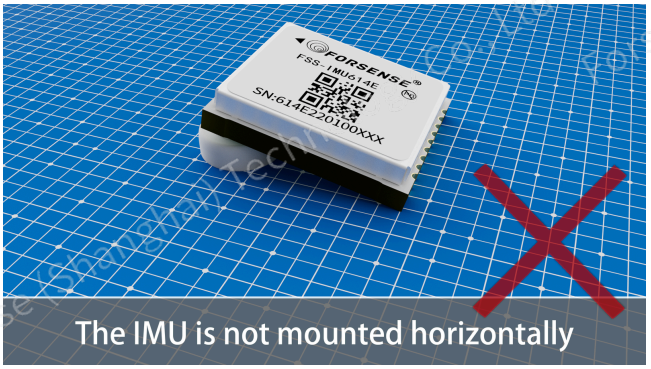
The following installation methods are incorrect.

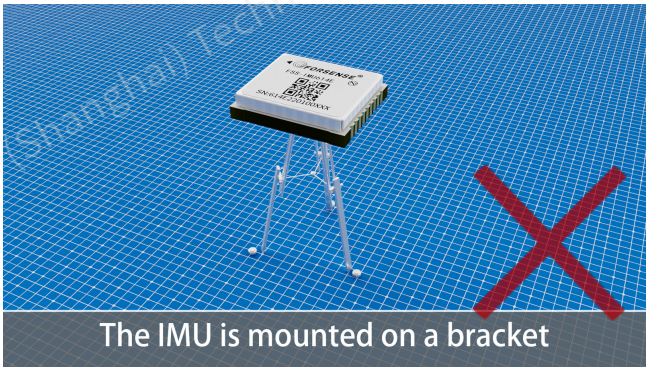
Figure 26 Incorrect Installation Diagram









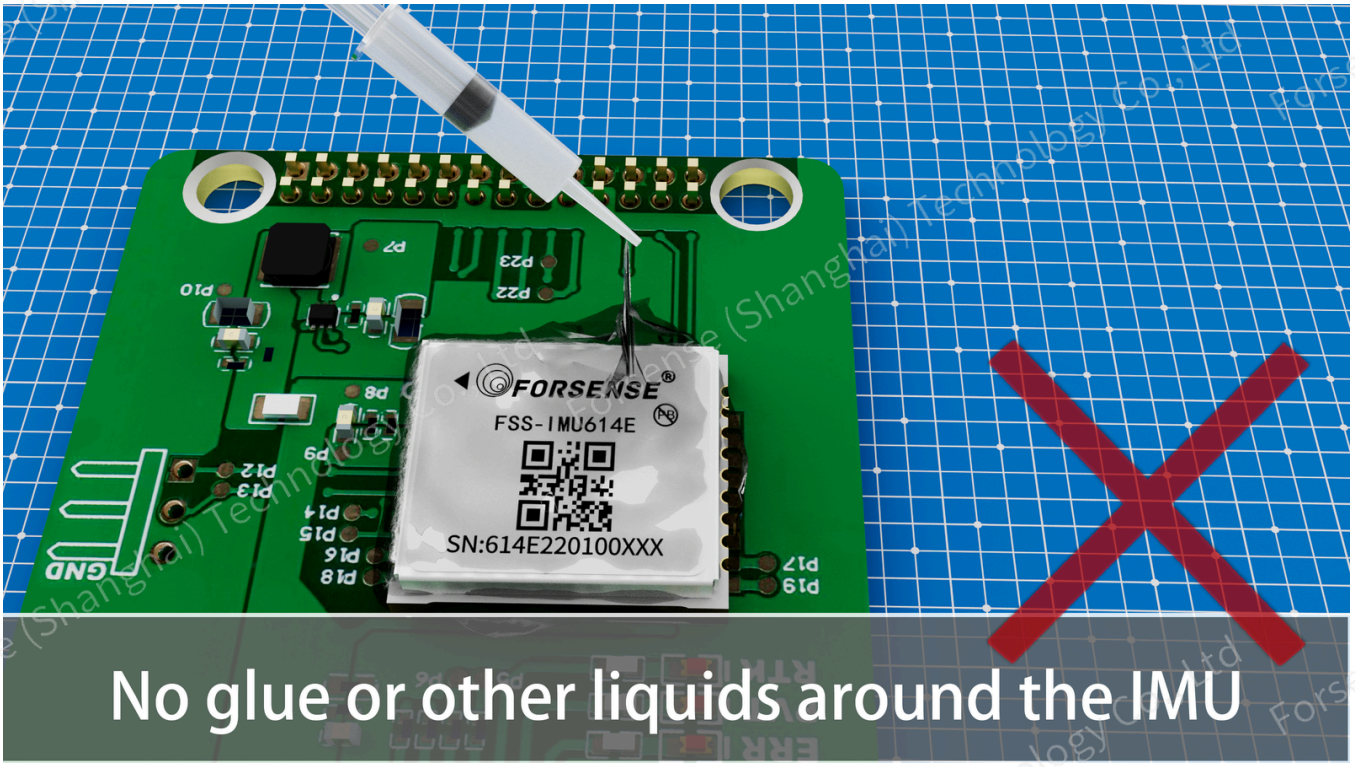




3. IMU Installation Precautions

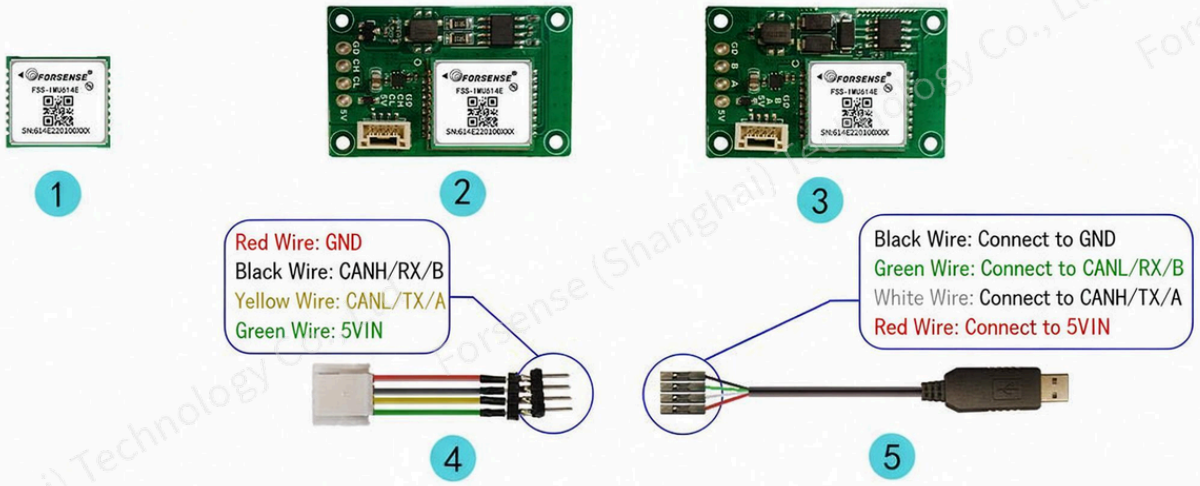
Do not apply adhesive or other flowing liquids around the IMU to prevent liquid from seeping into the IMU through gaps and affecting its performance.

Figure 27 Incorrect Installation Diagram

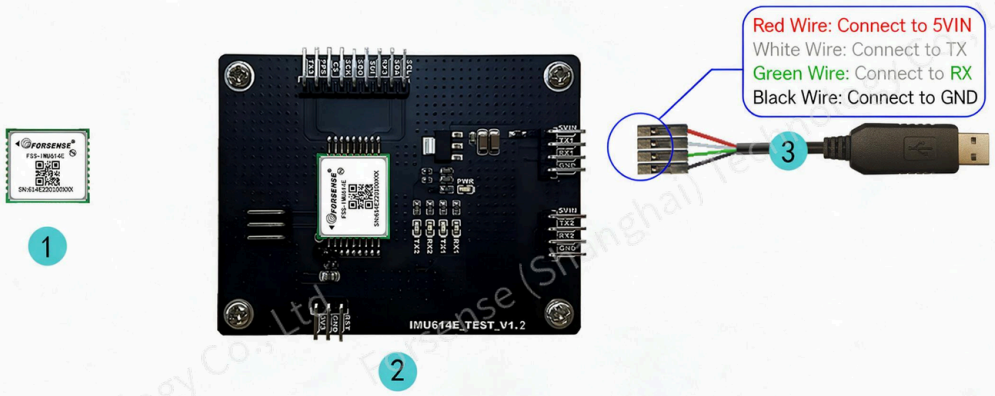


10.2 Connection PC software Example

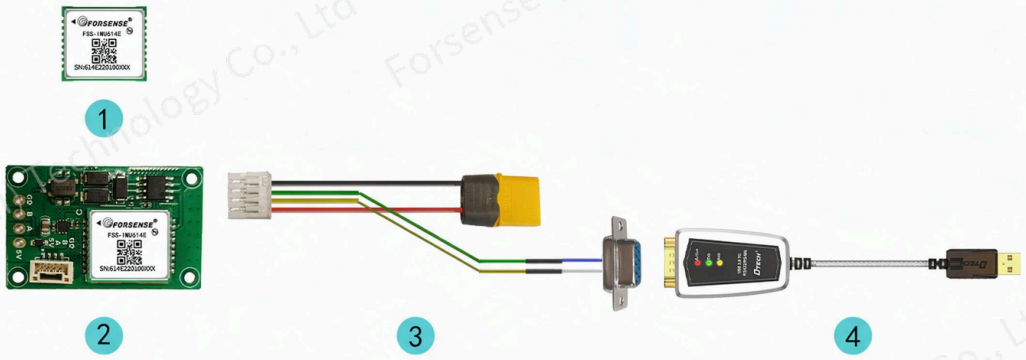
Figure 28 Module Connection PC software Diagram



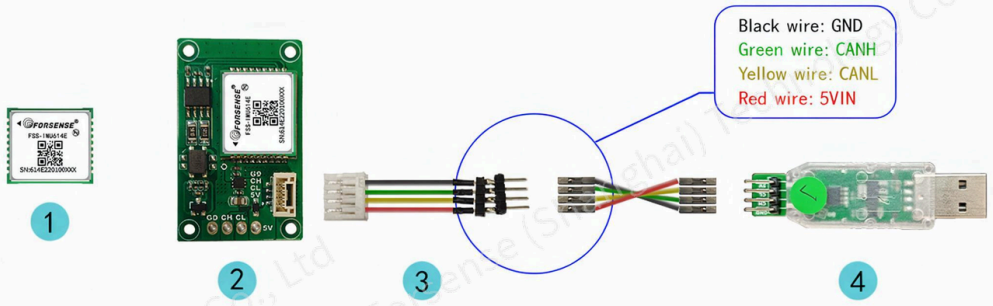
	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	SMD CAN Version Test Base Plate	1 pc
3	SMD 485 Version Test Base Plate	1 pc
4	4-PIN Connector	1 pc
5	TTL Serial Port Cable	1 pc



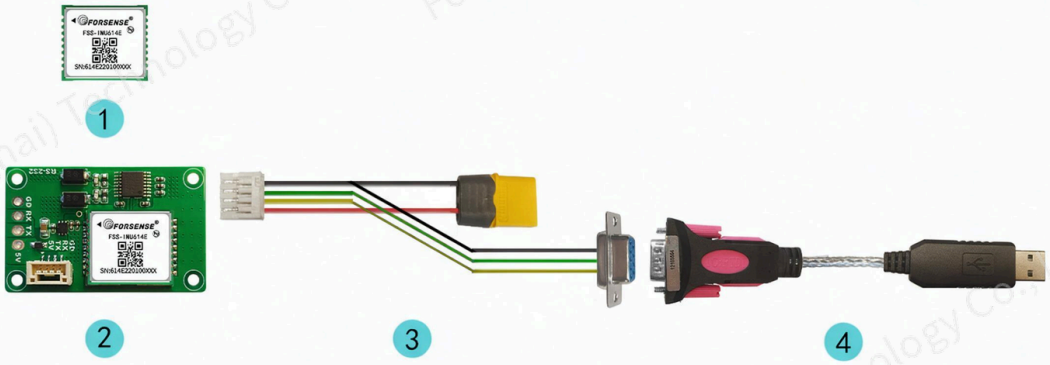
Name		Quantity
1	IMU614E Series Module	1 pc
Accessory Name		**Quantity**
2	IMU614E New Version Test Base Plate	1 pc
3	TTL Serial Port Cable	1 pc



	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	RS485 Version Test Base Plate	1 pc
3	RS485 Test Base Plate Test Harness	1 pc
4	RS485 to USB Adapter Cable	1 pc



	Name	Quantity
1	IMU614E Series Module	1 pc
	Accessory Name	Quantity
2	CAN Version Test Base Plate	1 pc
3	4-PIN Connector	1 pc
4	TTL Serial Port Cable	1 pc



	Name	**Quantity**
1	IMU614E Series Module	1 pc
	Accessory Name	**Quantity**
2	RS232 Version Test Base Plate	1 pc
3	RS232 Test Wiring Harness	1 pc
4	RS232 Serial Port Cable	1 pc

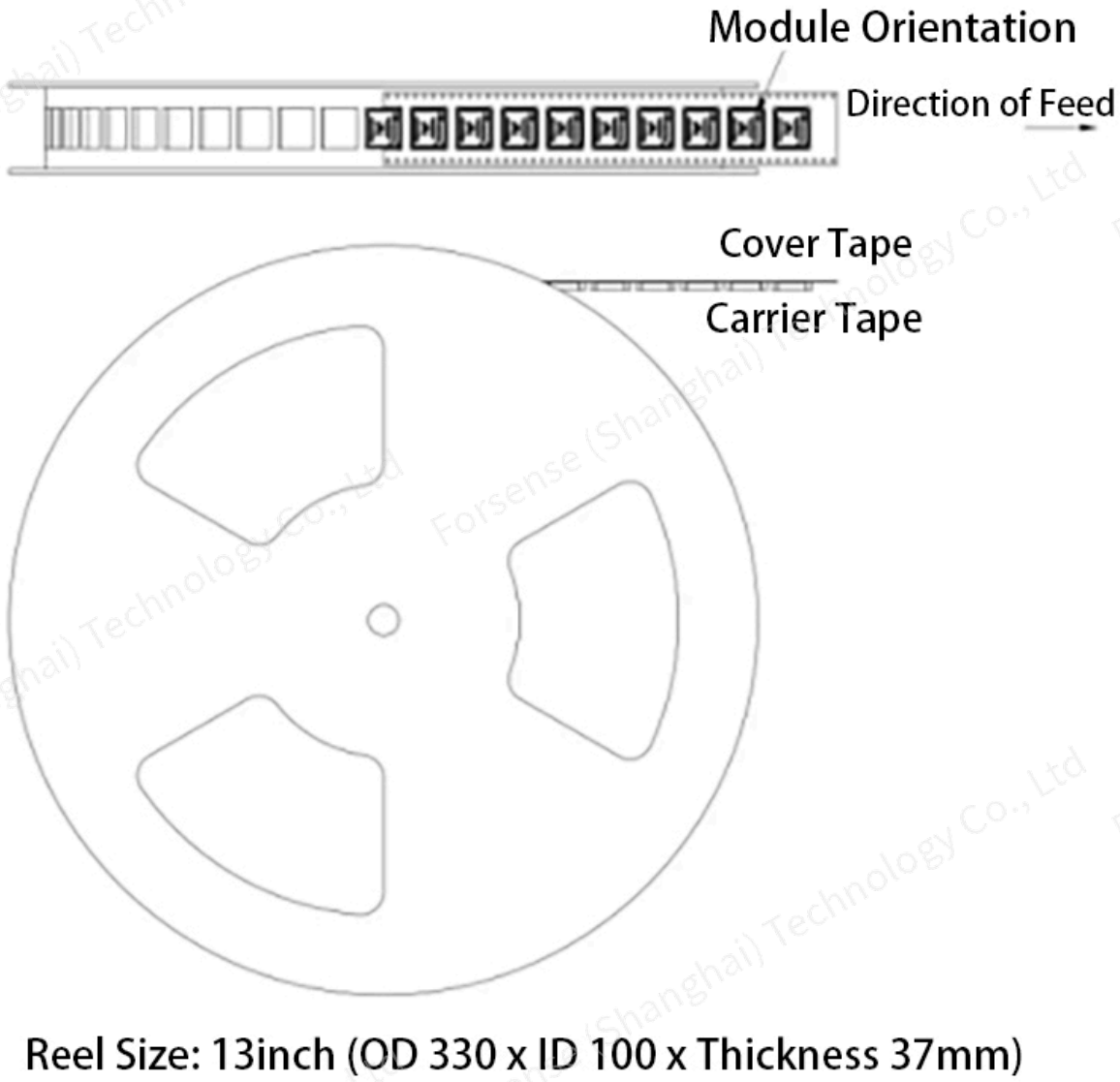
Forsense (Shanghai) Technology Co., Ltd

11. Packaging

The IMU614E-U module uses tape-and-reel sealed packaging to meet efficient production requirements.

11.1 Tape-and-Reel Packaging

Figure 29 Tape-and-Reel Packaging Diagram



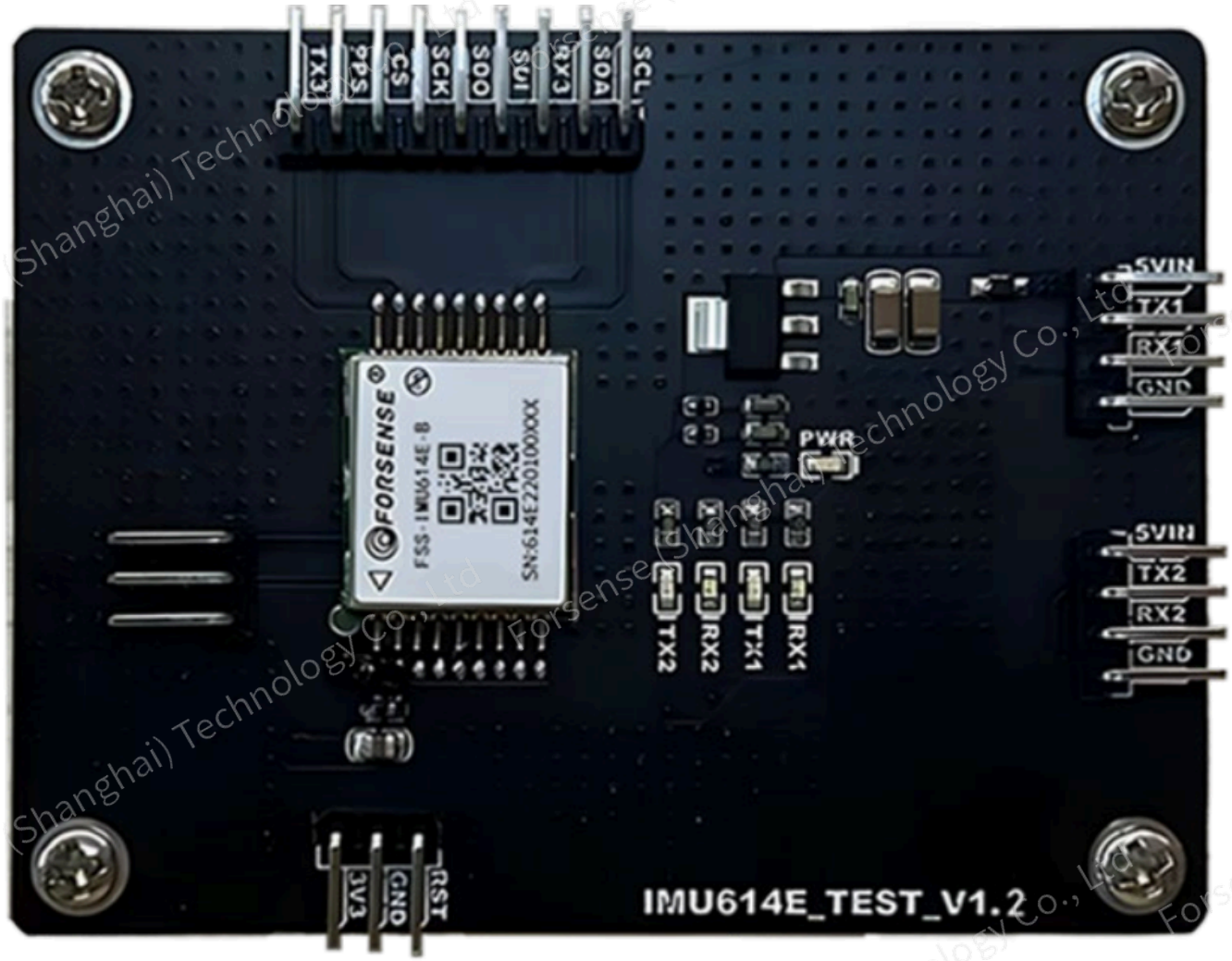
11.2 carrier tape

The position and orientation of the IMU614E-U module as placed on the carrier tape at factory shipment are shown in the figure below:

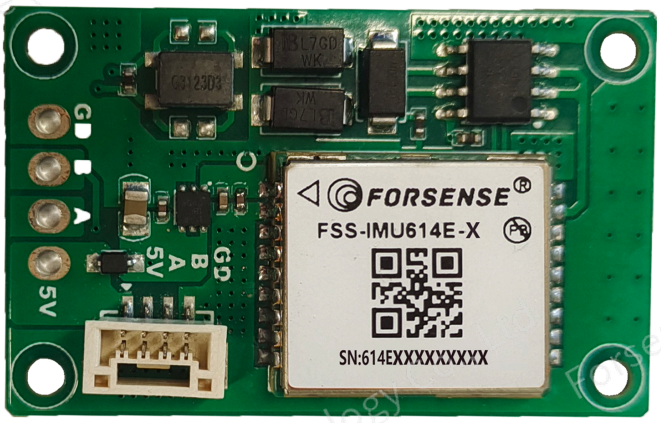
Figure30 Module Position and Orientation at carrier tape

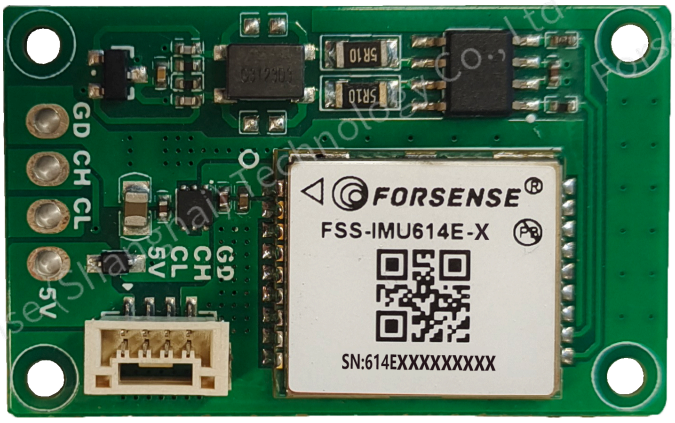


12. Optional AccessoriesAccessories



IMU614E-X Base Plate Test





IMU614E Series SMT RS-485 Version IMU614E Series SMT CAN Version



USB to CAN Module



TTL Serial Port Cable

13. UpdateRecord

Latest Manual Version: IMU614E-U_Datasheet_Product Manual(en)

Version	Date	Status/Notes
Version 1.0	2024.08.26	Initial Release
Version 1.1	2025.01.23	Adjusted table and figure numbering and chapter numbers
Version 1.2	2025.12.03	Updated dimensional drawings
Version 1.3	2025.12.24	Removed TTL test Base Plate
Version 1.4	2026.2.10	Update "SMT CAN Version IMU614E Series Test Base Plate","SMT RS-485 Version IMU614E Series Test Base Plate", "Recommended Pad Size"