FORSENSE
原极科技

Tactical MEMS 6 degrees of freedom (DOF) inertial sensor

FSS-IMU618-C Product manual

Features

Tactical grade MEMS Gyroscope

- 1.1°/hr Bias instability instability
- 0.09 Angle random walk°/√hr
- 0.1/s temperature drift (-40~85°C, <=1°C/ min@1σ)°

Tactic-grade MEMS accelerometer

- 15ug Bias instability instability
- 0.015 Speed random walkm/s/√hr
- 1.5 Temperature drift (-40~85°C, <=1°C/ min@1σ)mg

Large range of fine temperature compensation

- -40°C to 85°C temperature compensation
- Fine temperature calibration

Independent turntable calibration

- Independent calibration of each module: sensitivity, zero bias, non-orthogonal error
- Provide user calibration installation error interface

High strength working condition tolerance

- Strong impact tolerance: 2000g (0.5ms, half sine, 3 axis)
- Strong vibration tolerance: 10g (10~2KHz, 3 axis)
- Full temperature environment stable operation: -40°C ~ 85°C100% magnetic shield

Real-time and flexible digital interface, small size

- Configurable output sampling rate up to 1000Hz
- Support serial port, I2C, SPI multiple interfaces
- 23.7*23.7*9.9mm, weight only 10g

Product Overview

FSS-IMU618-C is a 6-DOF MEMS inertial sensor module built by FORSENSE Technology. Three-axis Gyroscope and acceleration information are provided as standard.

High precision, high resolution, can capture subtle vibration and tilt. Large range output makes motion perception possible under large dynamics. All modules are equipped with ultra-wide temperature range of fine warming and independent calibration before delivery, so that each module can play stably in various extreme conditions, while ensuring the performance of all products is highly consistent.

Application field

• Autonomous driving: vehicle, robot, engineering vehicle, underwater

• Precision measurement: downhole, tunnel, vibration, tilt

• Stable platform: PTZ, mobile communication,

• Navigation control: automatic control system, fixed wing UAV

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

Contents

1. Performance Parameter

1.1 Key indicators of gyroscope

Table 1 Key indicators of gyroscope

Parameter	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			+ 500		°/s
Zero bias instability	@, ALLAN variance, 1σ25℃		1.1		°/hr
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		47		Hz
Sampling rate			1000		Hz
Measurement delay			7.0		ms
Full temperature range zero deviation variation	-40 ~ 85℃, <=1℃/ min@1σ		0.1		°/s
Random Walk	@, ALLAN variance, 1σ25℃		0.09		$°/\sqrt{hr}$
Calibration coefficient error			2.0		‰
Calibration coefficient nonlinearity			200		ppm

Note 1: Limited by the bandwidth of the serial port, if the serial port baud rate is set to 115200, the maximum output frequency is 100Hz

Note 1σ change in zero deviation of total temperature at 2:1 ℃/ min

Note 3: IEEE standard, Allan variance curve given at static 25℃ environment

1.2 Key indicators of accelerometer

Table 2 Key indicators of accelerometer

Parameters	Test conditions/Remarks	Minimum value	Typical value	Maximum value	Units
Measuring range			Plus or minus 8		g
Zero bias	@, ALLAN variance,		15		μg

instability	1σ25℃				
Non-orthogonal between axes			0.02		deg
Internal low-pass cutoff frequency	Software adjustable		47		Hz
Sampling rate			1000		Hz
Measurement delay			7		ms
Full temperature range zero deviation variation	-40 ~ 85℃, <=1℃/ min@1σ		1.5		mg
Random Walk	@, ALLAN variance, 1σ25℃		0.015		$m/s/\sqrt{hr}$
Scale coefficient error			0.5		‰
Calibration coefficient nonlinearity			200		ppm

Note 1: Limited by the bandwidth of the COM, if the baud rate of the COM is set to 115200, the maximum output frequency is 100Hz

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

Note 3: IEEE standard, Allan variance curve given at static 25℃ environment

FIG. 1 ALLAN variance typical curve of gyroscope

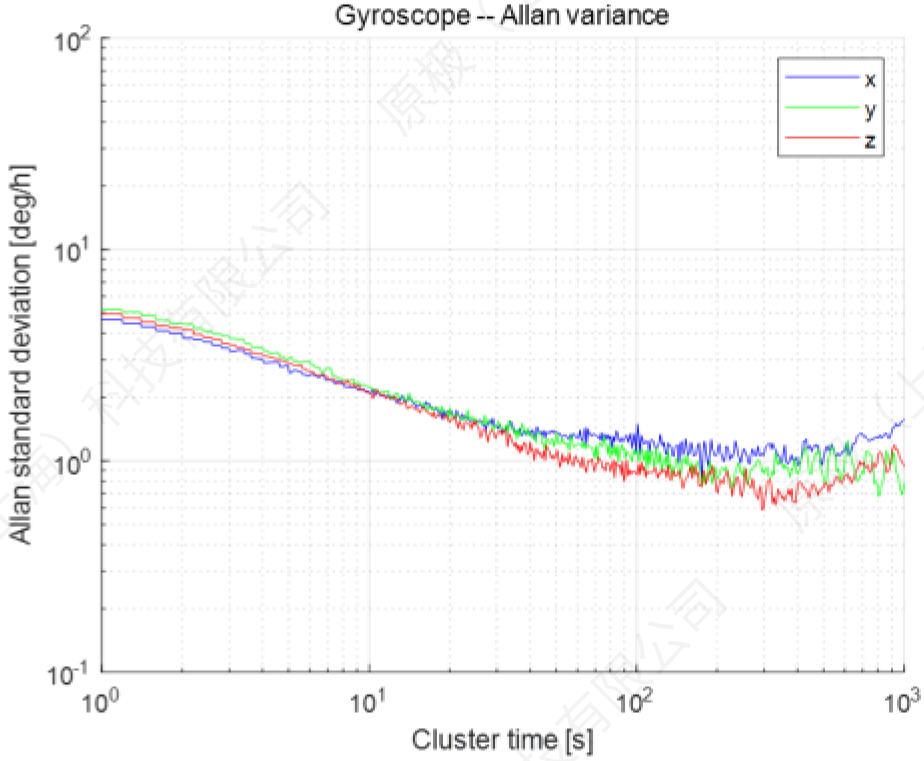
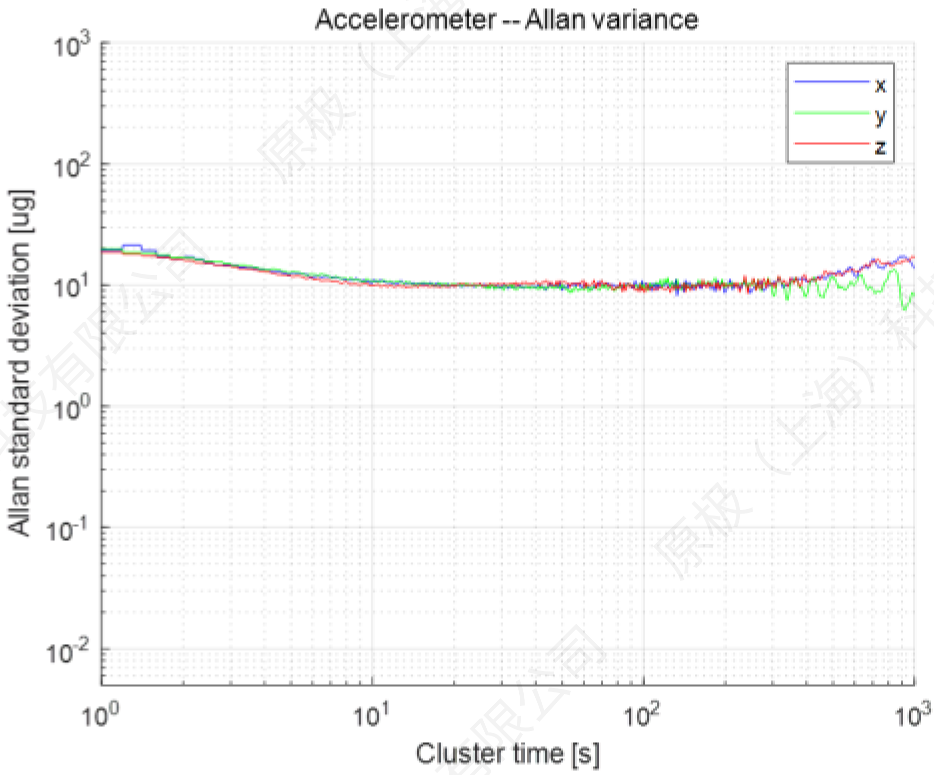


FIG. 2 Typical curve of ALLAN variance for accelerometer



2. External structure

Figure 3 Outline structure and size (unit: mm)

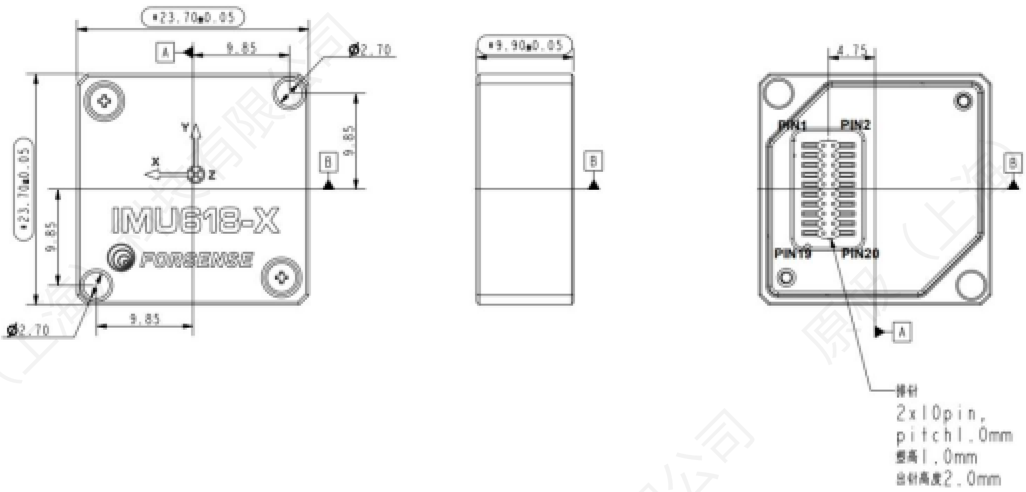


Figure 4 Location diagram of IMU measuring center (unit: mm)

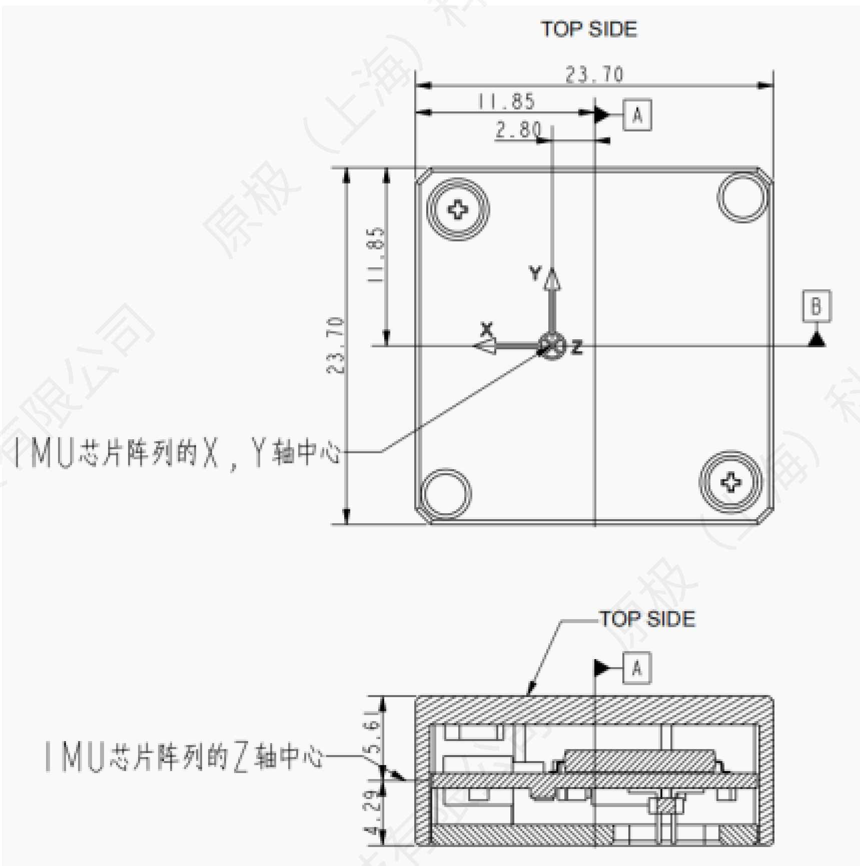
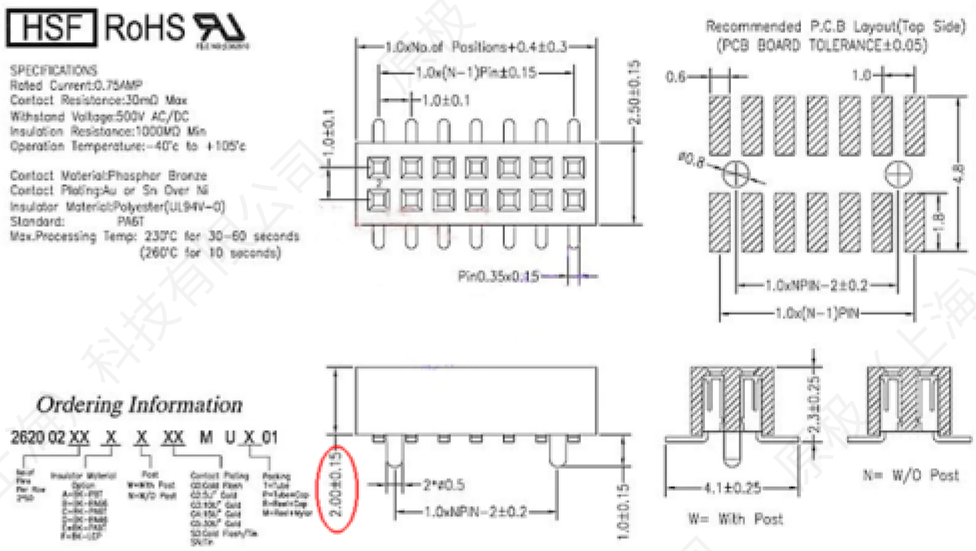


Figure 5 Specifications and Dimensions of reference pair bar (unit: mm)



3. Electrical characteristics

3.1 Maximum tolerance value

Table 3 Maximum absolute rating

Parameters	Symbols	Range	Units
Supply voltage	VCC	-0.3 to 4.0	V
Power source	GND	-	-
Input pin voltage	Vin	-0.3 to VCC+0.2	V
Use temperature	Tot	-40 to 85	℃
Storage temperature	Tstg	-40 to 85	℃

3.2 Working Conditions

Table 4 Working conditions

Parameters	Symbols	Minimum value	Typical value	Maximum value	Units
Supply voltage	VCC	3.2	3.3	3.4	V
VCC maximum ripple	Vrpp		+ 40		mV
Power Consumption	P		0.1		W
Use temperature	Tot	-40		85	℃
Storage temperature	Tstg	-40		85	℃

3.3 IO Threshold Characteristics

Table 5 I/O Threshold Characteristics

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

4 Pin definition

Figure 6 Pin schematic

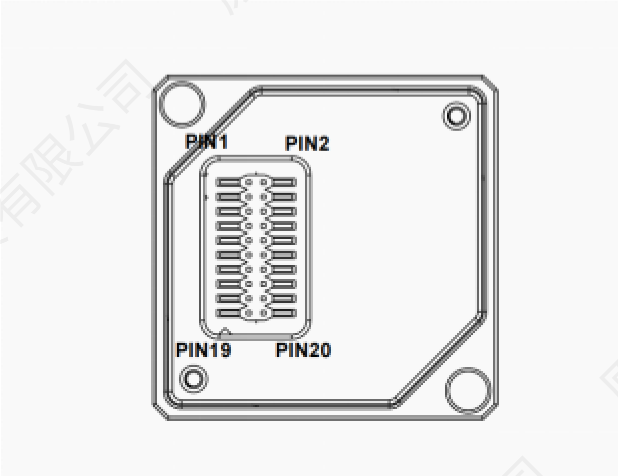


Table 6 Pin definitions

Pin Serial number	Pin name	Pin description
1	SCLK	SPI clock
2	SDO	SPI data MISO
3	GND	Power ground
4	GND	Power ground
5	SDI	SPI data MOSI
6	/CS	SPI slice selection
7	TX	Serial output
8	CAN_Tx	CAN port to send, suspended when not connected
9	RX	Serial input
10	NC	Connectionless
11	VCC	Power input, +3.3V input
12	VCC	Power input, +3.3V input
13	DRDY/SCL	Data Ready /I2C clock
14	EXT/SDA	External trigger sampling /I2C data
15	CAN_Rx	CAN port received, suspended when not connected
16	/RST	External hardware reset input
17	NC	Connectionless
18	NC	Connectionless
19	SEL	SPI/I2C mode control, suspended or connected low Level: SPI, High: I2C
20	NC	Connectionless

Note 1: The IMU hardware needs to be reset once using /RST during host initialization

5 Communication protocol

5.1 COM Communication Protocol

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

https://www.forsense.cn/download/

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

Stream mode: Periodically output AHRS data at a fixed frequency;

Command mode: In this mode, the periodic output is stopped, the user communicates with the IMU by sending commands, and the sensor data, status, parameters, etc. can be obtained through the GET command, and the parameters of the IMU can also be configured.

5.1.1 COM Interface Parameters

Table 7 COM interface parameters

Transmission rate range	115200bps to 1.5Mbps
Default transfer rate	115200bps
Start bit	1 bit
Data bits	8 bits
Stop bits	1 bit
Parity check	There is no

5.1.2 Packet Format

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

Table 8 IMU output and user input data structures

Offsets	Data type	Name	Description
0	uint8	Frame Header 1	IMU Output frame headers: 0xAA, 0x55 User input frame header: 0x55, 0xAA
1	uint8	Frame header 2	
2	uint16	ID low	The lower byte of the COM frame ID
3		ID high byte	The upper byte of the COM frame ID
4	uint16	Data length low	The lowest byte of the frame length of the COM communication. Length is the number of bytes occupied by the payload, that is, n
5		High data length	The upper byte of the frame length of the COM communication. Length is the number of bytes carried by the payload, that is, n
6	uint8	Payload (n bytes)	Data load
6+n	Uint32	CRC_CEHCK (32-bit data in low bytes)	CRC check
7+n		CRC_CEHCK (low byte in 32-bit data)	
8+n		CRC_CEHCK (high byte in 32-bit data)	
9+n		RC_CEHCK (32-bit data high byte)	

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

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

5.1.3 Data Flow frame — AHRS data

Table 9 Serial AHRS data format

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

Note 1: Maximum output update rate is not greater than 100Hz@115200bps

Table 10 COM A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	Mu s	Time scale
4	pitch	float	°	Pitch Angle
8	roll	float	°	Roll Angle
12	yaw	float	°	Heading Angle
16	ax	float	g	X-axis
20	ay	float	g	Y-axis
24	az	float	g	Z-axis
28	gx	float	°/s	X axis Angular
32	gy	float	°/s	Y-axis
36	gz	float	°/s	Z axis Angular
40	temp	float	℃	IMU chip

Example: Get AHRS data stream:

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

The analysis is as follows:

Table 11 AHRS data flow obtained from serial port A1

Descriptio	Raw Value	Analytic	Description	Raw Value	Analytic
ID	0200	02	Y-axis	BC74133C	0.009 g
Length	2C00	44	Z-axis	60E580BF	1.007 g
Time scale	6D891605	85363053	X axis	EC5138BD	0.045 ° / s
Pitch	8FC26540	3.59 °	Y-axis	0AD7A3BB	0.005 ° / s
Roll Angle	14AE07BF	0.53 °	Z axis	CDCCCCBC	0.025 ° / s
Heading	5C0FB243	356.12 °	IMU chip	D7A3EE41	29.83 ℃
X-axis	2506813D	0.063 g	crc32 Check	0CBF8480	2156183308

5.1.4 Command Mode GET Output -- System status

Table 12 serial port system status data format

	Frame Headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	S1	uint32
Coding	0xAA	0x55	0x00FF	0x002A		crc32

Note 1: The length of this frame varies according to the IMU model. All frames represent the length of S1 and need to be confirmed according to the IMU model.

Table 13 Load data format of COM S1

offset	Name	Data type	Description
0	Software_ver	uint32	Software version
4	Hardware_ver	uint32	Hardware version
8	rev	uint16	Reserved bytes
10	sn0	uint32	First SN number
14	sn1	uint32	Second SN

18	sn2	uint32	Third SN
22	Board_version	uint32	Baseboard version
26	Rev[16]	Uint8	All that follows

Note 1: Reserved bytes vary based on the IMU model. The IMU614E is 16 bytes.

For example, obtain the IMU 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 00 00 00 00 00 00 00 00 00 00 00 00 BD DB 31 34

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

Based on the response data, the resolution yielded software version number 211231(1F 39 03 00) and hardware version number 94053(65 6F 01 00).

5.1.5 Command Mode GET output -- Read parameters

Table 14 COM parameter input data format

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

Table 15 Output data format of COM parameters

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

Note 1 The IMU will turn the data stream off when reading the parameters, and will need to turn the data stream back on after setting.

Table 16 Load data format of COM P1

offset	Name	Data type	Description
0	Param1	float	Obtained Parameter (input data

4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the Parameter index
12	Param4	uint32	Reserved, the default value is
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Reserved. The default value is

Table 17 Index table of COM P1 load parameters

Param3	Param1	Units
3	The COM outputs the baud rate. The following baud	bps
4	Coordinate system orientation (see Table 24	
8	X-axis gyro zero bias calibration results, GYRO_X_OFF	°/s
9	Y-axis gyro zero bias calibration results, GYRO_Y_OFF	°/s
10	Z-axis gyro zero bias calibration results, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, define the same SPI	

Example: Get AHRS output frequency

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

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

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

5.1.6 Command mode SET instruction

Table 18 Serial port input command format

	Frame header	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	R1	uint32

Coding	0x55	0xAA	CMD	0x0018		crc32

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

Table 19 Load data format of COM R1

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

Table 20 Index table of COM R1 load parameters

CMD	Param1	Param3	Description
1	0	0	Trigger to get system status data once
2	0	0	Trigger to obtain AHRS data once
3	<mode>	0	< mode > Set the output mode: Mode=1, data stream output AHRS Mode=100 disables data stream mode and enters COMMAD mode
5	0	0	Save the current parameter to FLASH
6	0	<value>	Read the parameter, value is the index of the parameter to be read, that is, P1.index, see COM response output - Parameter read For example, to read AHRS output frequency (ODR), set value to 21 For example, to read the baud rate of the serial port, set value=3 For example, if you want to read the internal filter, set value=31 For example, if you want to read the coordinate system orientation, set value=4
9	0	0	Perform a software restart
14	<value>	3	Set the serial output baud rate, which is valid in bps value: 115200,230400,460800,921600,1500000 If value is other values, the default value is 115200bps After setting the baud rate parameter, you need to restart it for it to take effect. Procedure for setting the baud rate without power supply: Set the baud rate, save the parameter to the flash, and reset the software
14	<value>	21	Set the periodic AHRS data output frequency, common values in Hz value are: 1,10,50,100,200,500,1000 Recommended correspondence between the output frequency and the baud rate of the serial port 1000Hz: 921600bps 500Hz: 460,800bps 250Hz: 460800bps 200Hz: 460800bps 100Hz: 115,200 BPS

14	<value>	31	Internal filter configuration, defined as SPI accelerometer and gyro filter configuration, default 0xBB, i.e. 47Hz
14	<value>	4	Set the orientation of the IMU coordinate system. The value ranges from 101 to 124. See Table 24 for the corresponding relation of the orientation of the coordinate system

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

Note 2: The host computer command generator function can be used to generate corresponding commands to send, see the use of the host computer section of this manual

For example, to enable AHRS output:

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

5.1.7 Command Mode Output — User command response

Table 21 Setting parameters serial port response data format

	Frame header	Frame Headers	ID	length	ACK	Param3	Frame end
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32

Coding	0xAA	0x55	0x753D	0x0004	0x7534	Parameter index	crc32

Table 22 Reserved parameters Serial port response data format

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

Table 23 Serial user command response data format

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

Example: Set the serial output baud rate to 115200

Data input: 55, AA, 0 e, 00,18,00,00,00, E1, 47,00,00,00,00,03,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,56,2 B, 4 d, 93

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

Set the periodic AHRS data output frequency to 100hz

Input data: 55 AA 0E 00 18 00 00 00 00 C8 42 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0A 2B 2C 8D

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

Save the current parameter to FLASH

Enter data: 55 AA 05 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 C9 2F E6 32

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

Set output mode to AHRS data stream

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

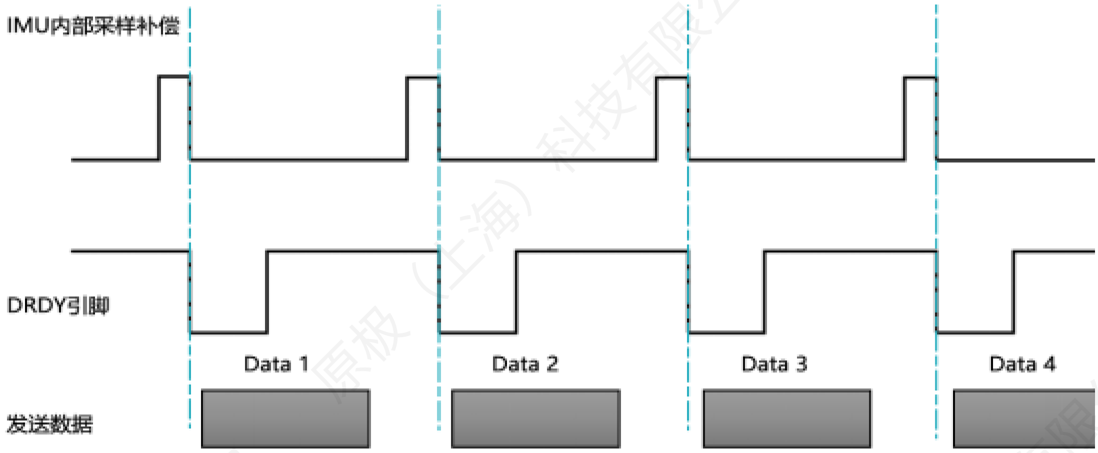
Response data: AA 55 64 00 04 00 03 00 01 00 E7 87 E3 AD

5.1.8 DRDY

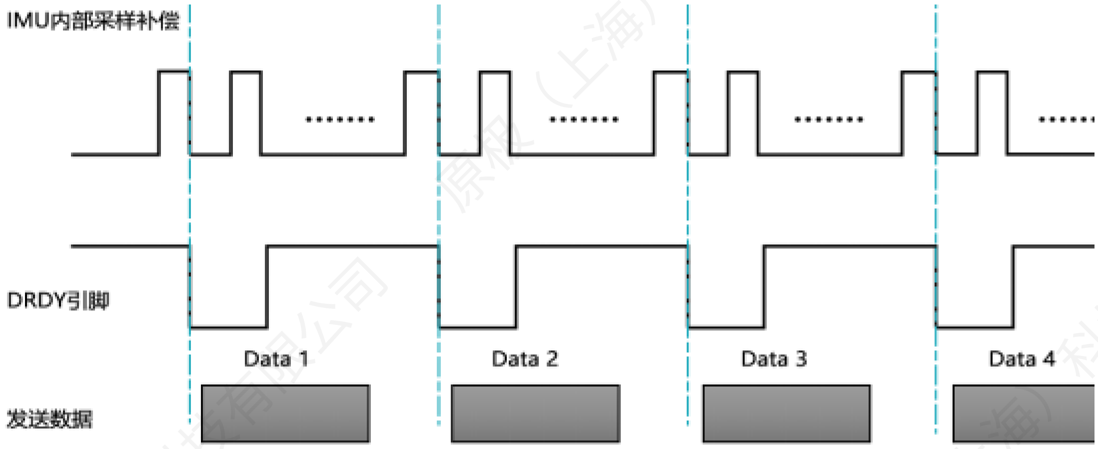
DRDY pin output serves two purposes:

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

2. Provide a signal to signal the start of transmitting data frames.



When the IMU internal sampling frequency (maximum ODR) is consistent with the output frequency of the COM (current ODR), the DRDY pin will be pulled down immediately after the IMU data sampling compensation is completed. At this time, the data frame will be sent from the COM. The DRDY pin will be pulled up again in the next cycle.

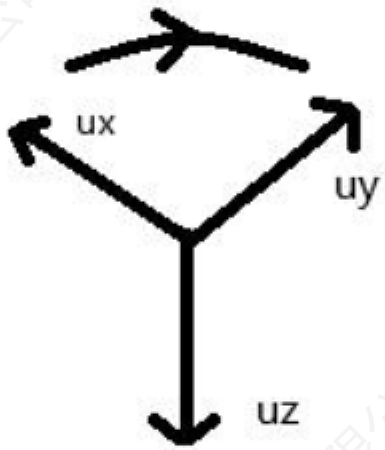


When the output frequency of the COM is less than the internal sampling frequency of the IMU, determine whether the DRDY pin is immediately lowered according to the frequency divider value (maximum ODR/ current ODR) after the IMU data sampling compensation is completed. After the DRDY is pulled down,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

5.1.9 Coordinate system setting function

Set the firmware coordinate system and display the corresponding firmware design coordinate system in the Upper computer software

Figure 7 Original firmware coordinate system



According to the above rule, after x and y axes are determined, z axis is determined. The Z axis is perpendicular to the plane from the X to the Y axis.

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

Table 24 coordinates are oriented towards the corresponding table

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

111	+Uy	+Uz	+Ux	
112	-Uy	-Uz	+Ux	
113	+Uz	+Uy	-Ux	
114	-Uz	-Uy	-Ux	
115	-Uy	+Uz	-Ux	
116	+Uy	-Uz	-Ux	
117	-Ux	+Uz	+Uy	
118	+Ux	-Uz	+Uy	
119	+Uz	+Ux	+Uy	
120	-Uz	-Ux	+Uy	
121	+Ux	+Uz	-Uy	
122	-Ux	-Uz	-Uy	
123	-Uz	+Ux	-Uy	
124	+Uz	-Ux	-Uy	

How to change the coordinate system to 102 orientation:

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

How to read the coordinate system orientation:

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

Example: Set the coordinate system to face 115

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

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

According to Table 21, the index of Parameter is 04, and the parameter is set successfully

Read the coordinate system:

Input data: 55 AA 06 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 69 64 09 E4

Response data: AA 55 30 75 18 00 00 00 00 E6 42 00 00 00 00 00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 B2 2F 2D 4E

According to Table 15 and Table 16, the resolution results in Parameter 1 being 115 (float) and Parameter 3 being 04. That is, the coordinate system is 115 orientation

5.1.10 COM Connection FAQs

1) The RX of the IMU cannot connect to two Master TX

The RX of the COM cannot be connected to two TX at the same time. Therefore, if the Forsense upper machine needs to be connected, it needs to disconnect the communication with the COM of the user's host. Otherwise, the upper computer cell can only receive data and cannot send commands to the IMU.

As shown in the following picture:

Figure 8 Schematic diagram of COM connection

2) The version number cannot be obtained

You are advised to use the COM of the FT232 chip. CH340 and PL2303 data cables may lose packets when the baud rate is high (>115200bps)

It is recommended that COM be connected directly, and it is not recommended to be connected in series. If the interface of RS422 is connected to the computer, directly use RS422 to USB cable, and do not use RS422 to RS232+RS232Z to USB cable in series.

3) Upper computer software curve display lag

If it is an FT232 data line, use the system administrator to open the Upper computer software and automatically configure the COM delay

Manually configure COM delay in Device Manager.

5.2 I2C Communication Protocol

Stm32-based I2C Master read driver example:

https://www.forsense.cn/download/

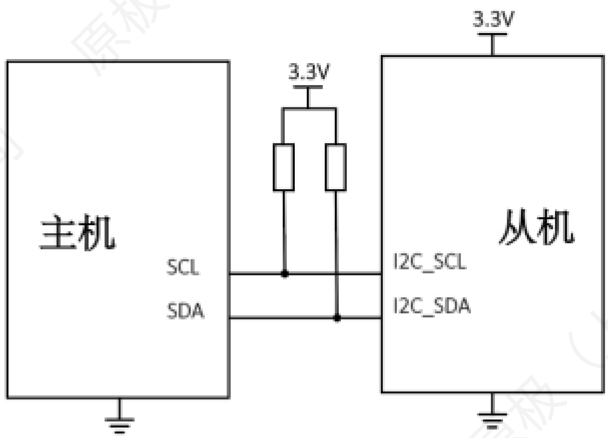
5.2.1 Parameter of the I2C interface

Table 25 I2C interface Parameter

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

5.2.2 I2C Connection Method

Figure 9 I2C connection method



Note: The pull-up resistor value of 4.7KΩ

5.2.3 I2C register

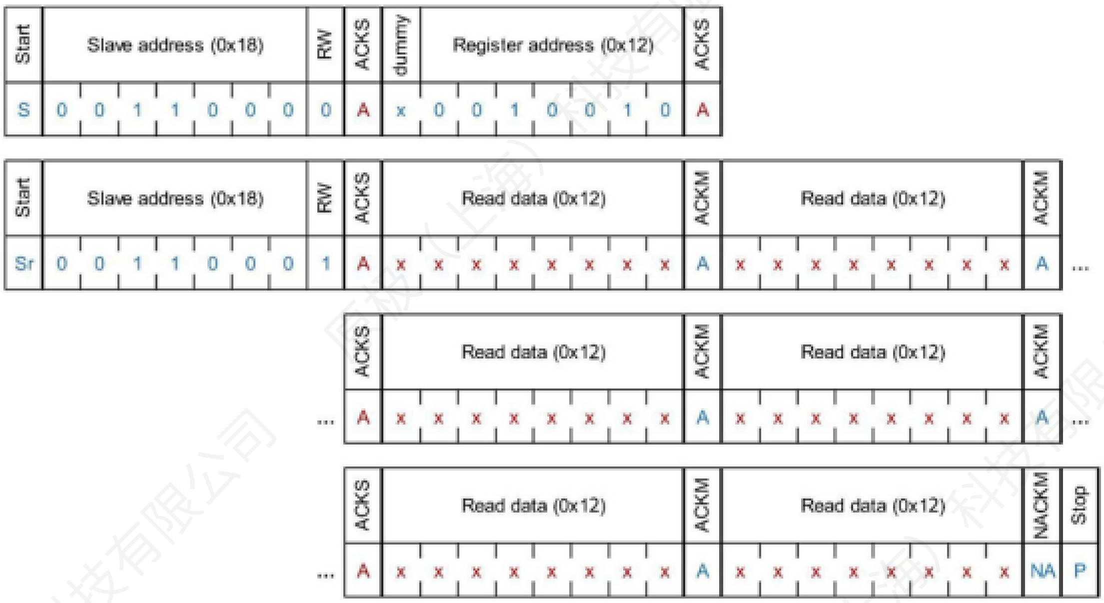
Table 26 List of I2C registers

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

5.2.3.1 I2C BURST Register

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

Figure 10 I2C continuous read mode



Frames are defined as follows:

Table 27 I2C continuous read data format

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

Data format	float	float	float
Send content	ACCL_Z	GYRO_X	GYRO_Y
Send order	7	8	9
Data format	float	float	uint32
Send content	GYRO_Z	TEMP	CRC32

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

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

5.2.3.2 I2C FILTER_CTRL register

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

Figure 11 I2C FILTER_CTRL register writing method

5.2.3.3 I2C ID Register

The ID register is 0x6A and contains the ASCII character IMU61B, which can be read from I2C BURST, as shown in the following table.

Table 28 I2C ID register read mode

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

Note 1: All data is 8-bit width

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

5.3 SPI Communication Protocol

Example of SPI host read driver based on STM32:

https://www.forsense.cn/download/

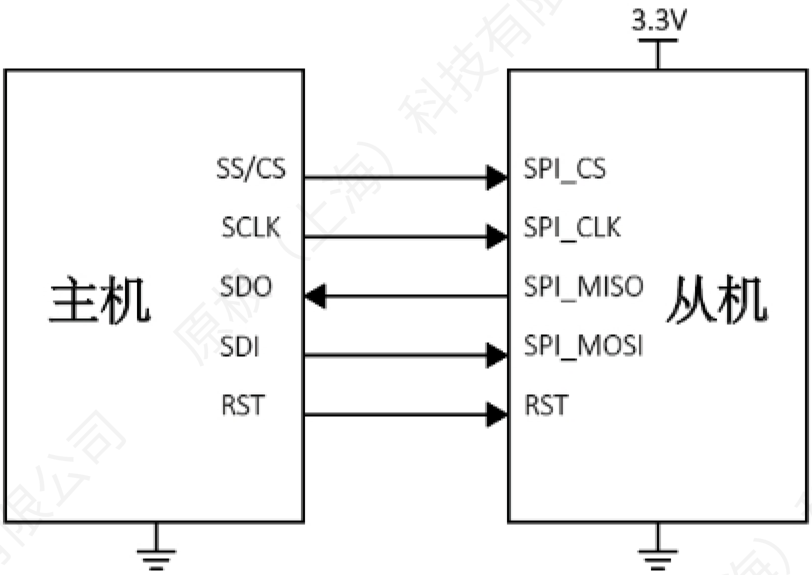
5.3.1 SPI Interface Parameters

Table 29 SPI interface parameters

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

5.3.2 SPI connection diagram

Figure 12 SPI connection diagram



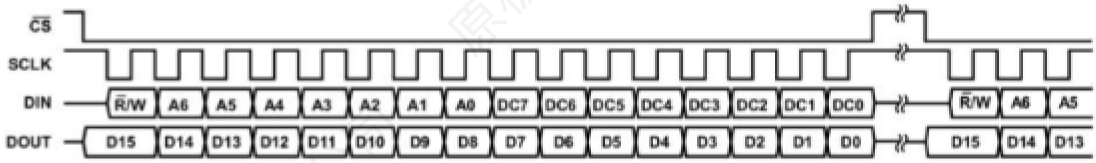
Note 1: Before the initial reading, it is necessary to reset the IMU and wait for 3s to make the IMU enter the normal working state.

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

5.3.3 SPI communication bit order

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

FIG. 13 Schematic diagram of SPI communication bit order



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

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

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

5.3.4 SPI register

Table 30 List of SPI registers

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

			0x3142	1	ID number 3 (IMU6132B)
WIN_CTRL	0x7F, 0x7E	RW	0x0000	0, 1	Window ID
TEMP_HIGH	0x0E	R	\	0	Temperature
TEMP_LOW	0x10	R	\	0	Temperature low
XGYRO_HIGH	0x12	R	\	0	Gyro X axis
XGYRO_LOW	0x14	R	\	0	Gyro X axis low
YGYRO_HIGH	0x16	R	\	0	Gyro Y-axis
YGYRO_LOW	0x18	R	\	0	Gyro Y axis low
ZGYRO_HIGH	0x1A	R	\	0	Gyro z-axis
ZGYRO_LOW	0x1C	R	\	0	Gyro Z axis low
XACCEL_HIGH	0x1E	R	\	0	Add table X axis
XACCEL_LOW	0x20	R	\	0	Add table X axis
YACCEL_HIGH	0x22	R	\	0	Add table Y-axis
YACCEL_LOW	0x24	R	\	0	Add table Y-axis
ZACCEL_HIGH	0x26	R	\	0	Add table Z-axis
ZACCEL_LOW	0x28	R	\	0	Add table Z axis

5.3.4.1 SPI BURST register

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

Table 31 Format of SPI BURST register

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

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

Figure 14 Schematic diagram of continuous reading of SPI BURST

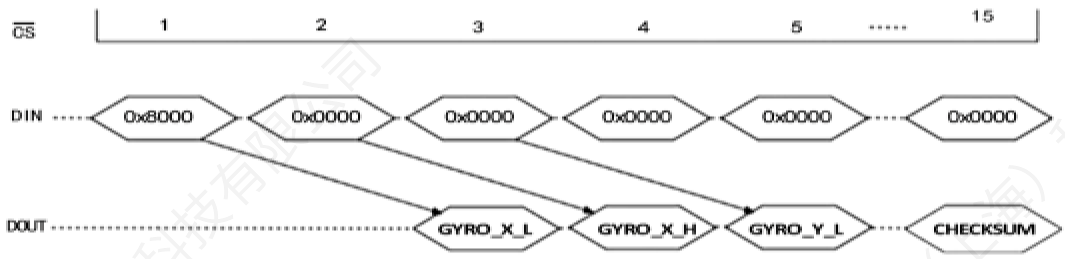


Table 32 Basic format of continuous reading by SPI BURST

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

Note 1: All data are 16-bit widths

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

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

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

Figure 15 Schematic diagram of SPI32 bit data restoration

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

Table 33 Standard frame SPI 32-bit data conversion formula

Name	Units	Formula	Conditions/Notes
Angular Speed	°/s	G=SF/65536*GYRO	GYRO is the GYRO data for the X/Y/Z axis in the table above Gyro scale factor SF = 0.016
Acceleration	mg	A=SF/65536*ACCL	ACCL is the ACCL data for the X/Y/Z axis in the table above For Burst mode, SF = 0.2 In single Register mode, SF=0.2/1000
Temperature	℃	T=SF/65536*TEMP-172621824+25	TEMP is the TEMP data in the table above Temperature scale factor SF =-1/263.4
Attitude Angle	°	D=SF/65536*ATT	ATT is the ATT data in the table above Attitude scale factor SF = 0.00699411

5.3.4.2 SPI FILTER_CTRL Register

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

Table 34 SPI FILTER_CTRL Register format

Address	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8	Read/ Write

0x07									RW
Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Read/ Write
0x06	Accelerometer filter configuration				Gyro filter configuration				RW

Table 35 Filter configuration

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

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

5.3.4.3 SPI ID Register

The ID Register is a read-only Register, and the data content is the ASCII encoded character "IMU". The reading method is similar to that of BURST data reading: 0x6A00~0x7000 is sent when the burst data is read, and the data is received. The output Register content is offset by 2 cycles from the read instruction sending.

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

Table 36 Format of SPI ID Register

Address	bit15 ~ bit0	Encoding	Read/Write
0x6C	PROD_ID1	0x494D	R

0X6E	PROD_ID2	0x5536	R
0x70	PROD_ID3 The encoded content represents the	0x3132(IMU612)	R
		0x3134(IMU614)	R
		0x3138(IMU618)	R
		0x3141(IMU6132A)	R
		0x3142(IMU6132B)	R

5.3.4.4 SPI WIN_CTRL Register

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

Table 37 SPI WIN_CTRL Register format

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

Table 38 SPI register WIN_CTRL.WINDOW_ID encoding

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

6. Coordinate system definition

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

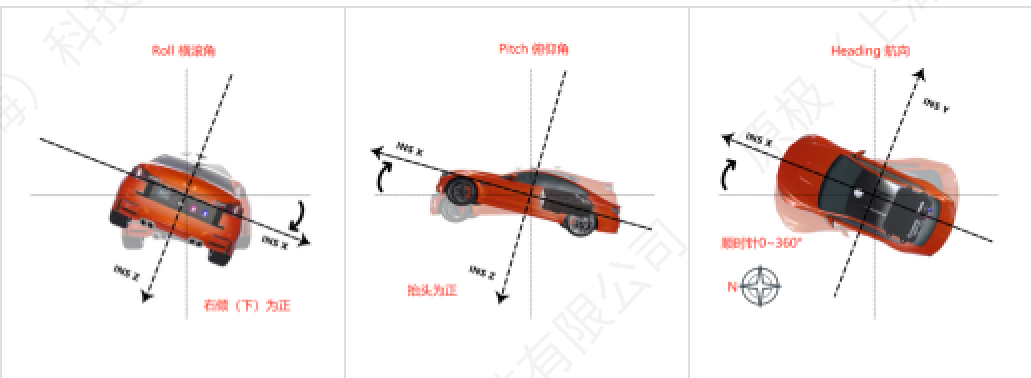
Rotation around the Z axis: Yaw angle Yaw range: 0° ~360°;

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

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

Roll, pitch, course Angle diagram is as follows:

FIG. 21 Schematic diagram of roll, pitch and Yaw angle



7. CRC table lookup method calculation

```
C++
  static const uint32_t crc32_tab [ ] = {
  0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419, None 706Af48F
  ,0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4, 0xe0d5e91e, 0x97d2d988
  ,0x09b64c2b, 0x7eb17cbd, 0xe7b82d07, 0x90bf1d91, 0x1db71064, 0x6ab020f2
  ,0xf3b97148, 0x84be41de, 0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7
  ,0x136c9856, 0x646ba8c0, 0xfd62f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9
  ,0xfa0f3d63, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd56041e4, 0xa2677172
  ,0x3c03e4d1, 0x4b04d447, 0xd20d85fd, 0xa50ab56b, 0x35b5a8fa, 0x42b2986c
  ,0xdbbbc9d6, 0xacbcf940, 0x32d86ce3, 0x45df5c75, 0xdcd60dcf, 0xabd13d59
  ,0x26d930ac, 0x51de003a, 0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423
  ,0xcfba9599, 0xb8bda50f, 0x2802b89e, 0x5f058808, 0xc60cd9b2, 0xb10be924
  ,0x2f6f7c87, 0x58684c11, 0xc1611dab, 0xb6662d3d, 0x76dc4190, 0x01db7106
  ,0x98d220bc, 0xefd5102a, 0x71b18589, 0x06b6b51f, 0x9fbfe4a5, 0xe8b8d433
  ,0x7807c9a2, 0x0f00f934, 0x9609a88e, 0xe10e9818, 0x7f6a0dbb,  0x086d3d2d
  ,0x91646c97,  0xe6635c01,  0x6b6b51f4,  0x1c6c6162,  0x856530d8,
0xf262004e
  ,0x6c0695ed,  0x1b01a57b, 0x8208f4c1, 0xf50fc457, 0x65b0d9c6, 0x12b7e950
  ,0x8bbeb8ea, 0xfcb9887c, 0x62dd1ddf, 0x15da2d49, 0x8cd37cf3, 0xfbd44c65
  ,0x4db26158, 0x3ab551ce, 0xa3bc0074, 0xd4bb30e2, 0x4adfa541, 0x3dd895d7
  ,0xa4d1c46d, 0xd3d6f4fb, 0x4369e96a, 0x346ed9fc, 0xad678846, 0xda60b8d0
  ,0x44042d73, 0x33031de5, 0xaa0a4c5f, 0xdd0d7cc9, 0x5005713c,  0x270241aa
  ,0xbe0b1010,  0xc90c2086,  0x5768b525,  0x206f85b3,  0xb966d409,
0xce61e49f
  ,0x5edef90e,  0x29d9c998, 0xb0d09822, 0xc7d7a8b4, 0x59b33d17, 0x2eb40d81
  ,0xb7bd5c3b, 0xc0ba6cad, 0xedb88320, 0x9abfb3b6, 0x03b6e20c, 0x74b1d29a
  ,0xead54739, 0x9dd277af, 0x04db2615, 0x73dc1683, 0xe3630b12, 0x94643b84
  ,0x0d6d6a3e, 0x7a6a5aa8, 0xe40ecf0b, 0x9309ff9d, 0x0a00ae27, 0x7d079eb1
  ,0xf00f9344, 0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d,  0x806567cb
  ,0x196c3671,  0x6e6b06e7,  0xfed41b76,  0x89d32be0,  0x10da7a5a,
0x67dd4acc
  ,0xf9b9df6f,  0x8ebeeff9,  0x17b7be43,  0x60b08ed5,  0xd6d6a3e8,
0xa1d1937e
```

```
,0x38d8c2c4, 0x4fdff252, 0xd1bb67f1, 0xa6bc5767, 0x3fb506dd,
0x48b2364b
,0xd80d2bda, 0xaf0a1b4c, 0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55
,0x316e8eef, 0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236
,0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe, 0xb2bd0b28
,0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31, 0x2cd99e8b, 0x5bdeae1d
,0x9b64c2b0, 0xec63f226, 0x756aa39c, 0x026d930a, 0x9c0906a9,
0xeb0e363f
,0x72076785, 0x05005713, 0x95bf4a82, 0xe2b87a14, 0x7bb12bae,
0x0cb61b38,0x92d28e9b
, 0xe5d5be0d, 0x7cdcefb7, 0x0bdbdf21, 0x86d3d2d4, 0xf1d4e242,0x68ddb3f8
, 0x1fda836e, 0x81be16cd, 0xf6b9265b, 0x6fb077e1, 0x18b74777,0x88085ae6
, 0xff0f6a70, 0x66063bca, 0x11010b5c, 0x8f659eff, 0xf862ae69,0x616bffd3
, 0x166ccf45, 0xa00ae278, 0xd70dd2ee, 0x4e048354, 0x3903b3c2
,0xa7672661, 0xd06016f7, 0x4969474d, 0x3e6e77db, 0xaed16a4a,
0xd9d65adc,0x40df0b66
, 0x37d83bf0, 0xa9bcae53, 0xdebb9ec5, 0x47b2cf7f,
0x30b5ffe9,0xbdbdf21c
, 0xcabac28a, 0x53b39330, 0x24b4a3a6, 0xbad03605, 0xcdd70693,0x54de5729
, 0x23d967bf, 0xb3667a2e, 0xc4614ab8, 0x5d681b02, 0x2a6f2b94,0xb40bbe37
, 0xc30c8ea1, 0x5a05df1b, 0x2d02ef8d
,}
uint32_t crc_crc32 (uint32_t crc, const uint8_t *buf, uint32_t
size ) {for (uint32_t
 i=0; i<size ; i++) {crc
= crc32_tab [ (crc ^ buf [i ] ) & 0xff] ^ (crc >> 8 ) ;
}
return crc;
}
```

8 Use examples

8.1 Device Installation

1. The module should be firmly fixed on a rigid plane to avoid being installed in a position with large vibration.

2. The module should be installed in the same direction as the front.

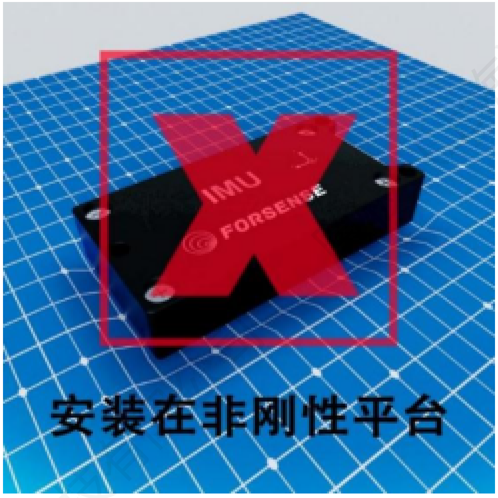
Figure 16 Schematic diagram of module installation

The correct installation diagram is as follows

The X axis faces the front of the car

Figure 17 Diagram of proper installation

The following installation methods are incorrect installation




IMU
FORSENSE
IMU悬空于载具之外

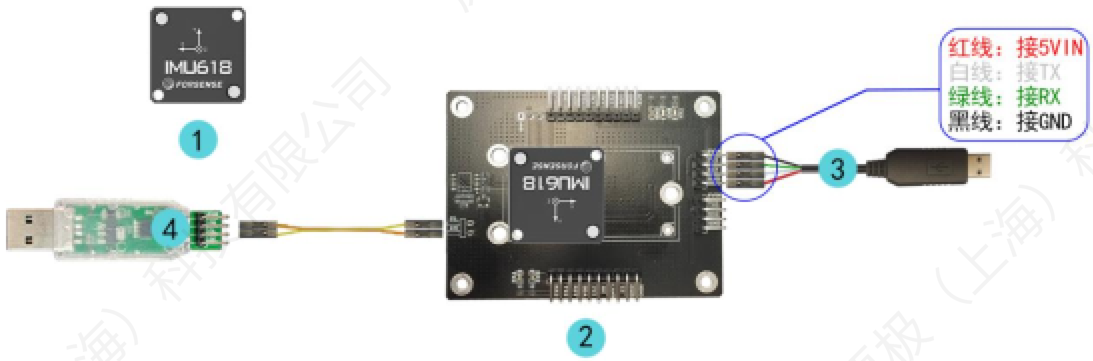

FORSENSE
请勿用手固定


IMU
FORSENSE
不能安装在支架上


IMU
FORSENSE
IMU X轴应朝向车头

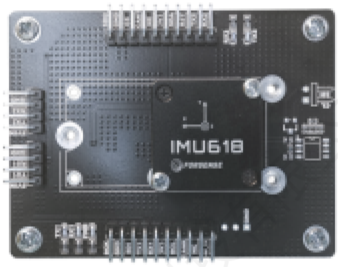
8.2 Example for Connecting a Upper computer software

Figure 18 Schematic diagram of module connecting to Upper computer software



	名称	数量
1	IMU618	1个
	附件名称	数量
2	IMU618测试底板	1个
3	TTL串口线	1个
4	USB转CAN模块	1个

9. Select accessories



IMU618 Tests the Base Plate

TTL COM

USB to CAN module

10. Update your records

Versions	Dates	Status/Comments
Version 1.0	2024.03.29	First Issue
Version 1.1	2024.05.10	Add Upper computer software connection diagram