FORSENSE
原极科技

Dynamic inclination measurement module

FSS-AHRS40X-X Product manual

Features

Tactical grade MEMS IMU

- 2.5°/h gyroscope zero bias instability
- 25ug accelerometer zero bias instability

Anti-interference dynamic tilt algorithm

- Resolution 0.01 degrees
- Low dynamic accuracy <0.4° @rms

Independent turntable calibration

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

High strength condition tolerance

- Strong impact tolerance: 2000g (0.5ms, half sine, 3 axis)
- Strong vibration tolerance: 10g (10~2KHz, 3 axis)
- Full temperature environment stable operation: -40℃ ~ 85℃
- 100% magnetic shielding

Real-time and flexible digital interface, small size

- Configurable output sampling rate up to 1KHz
- CAN interface support
- Support RS-485 interface
- Support TTL interface
- RS-232 interface is supported

Product Overview

AHRS40X is a dynamic inclination measurement sensor launched by Yuanji Technology based on industrial IMU platform for construction machinery, intelligent robots and other fields. All modules are equipped with ultra-wide temperature range of fine warming and independent calibration before delivery to ensure the consistency and stability of the module. Built-in attitude fusion

algorithm based on extended Kalman filter can effectively suppress the influence of dynamic interference on attitude accuracy and ensure the stability of attitude accuracy.

Application Areas

- Automatic driving of agricultural machinery
- Engineering Car
- Underwater robot
- Static and dynamic inclination monitoring, vibration monitoring

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

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FSS-AHRS40X-X Product Sheet

Contents

1. Performance parameters

AHRS40X-X product performance indicators are shown in Table 1 below:

Table 1 Performance indicators

Sensor Performance	
Angle measuring range	Pitch Angle: ±80° Roll Angle: ±180°
Angle repeatability	< 0.03 °
Angular velocity measurement range	±450°/s ±2000°/s 2
Resolution	0.01 °
Dynamic accuracy 1	0.4 °
Acceleration measurement range	±6g
Update rate	U1
Electrical characteristics	
Voltage input	5 V / 9-32 V 3
Power Consumption	0.2 0.36 W
Interface	CAN/RS-485/RS-232/TTL
Physical Characteristics (AHRS400-X)	
Connector type	GX12-4 core (male head)
Product size	55 * 37.6 * 24 mm
Waterproof rating	IP68
Cable length	40cm(self-contained) + 50cm(external)
Physical characteristics (AHRS40X-A)	
Connector type	M12 Aviation Connector 5 pin (male/female)
Product size	**AHRS** 401 : 47*85*24mm **AHRS** 402:47*96.5*24mm
Waterproof rating	IP68
Cable length	40cm(self-contained) + 50cm(external)
Ambient temperature	
Operating temperature	- 40 ~ 85 ℃
Storage temperature	- 40 ~ 85 ℃

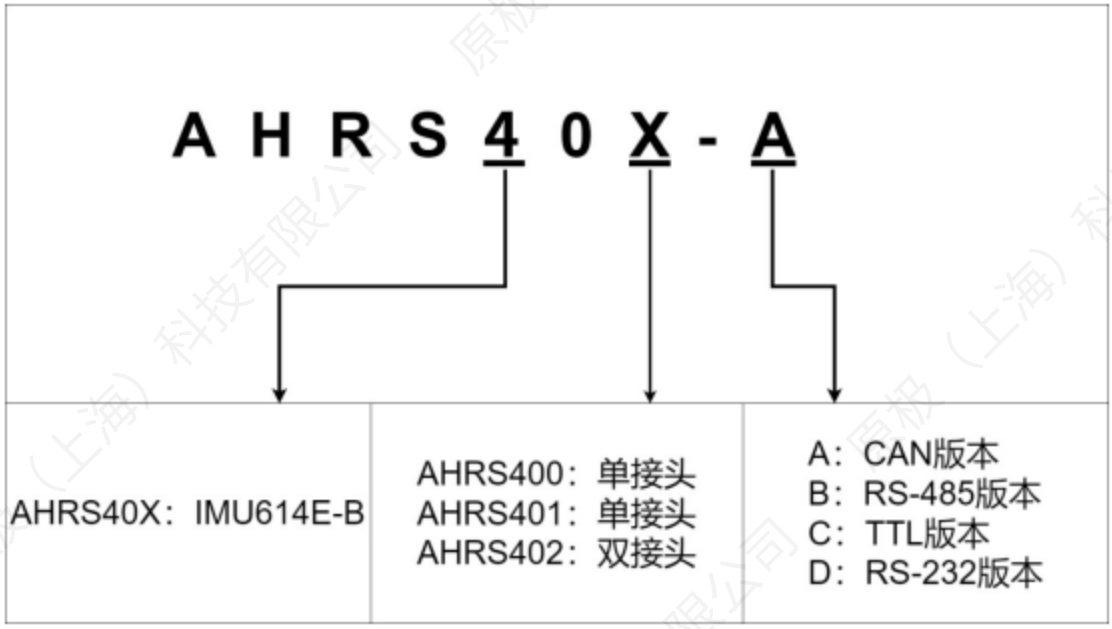
1 For vehicle-mounted low dynamic scenarios, the RMS error value after deducting the installation deviation Angle

2 Require special firmware support

3 5V is a separate voltage version

2 Model description

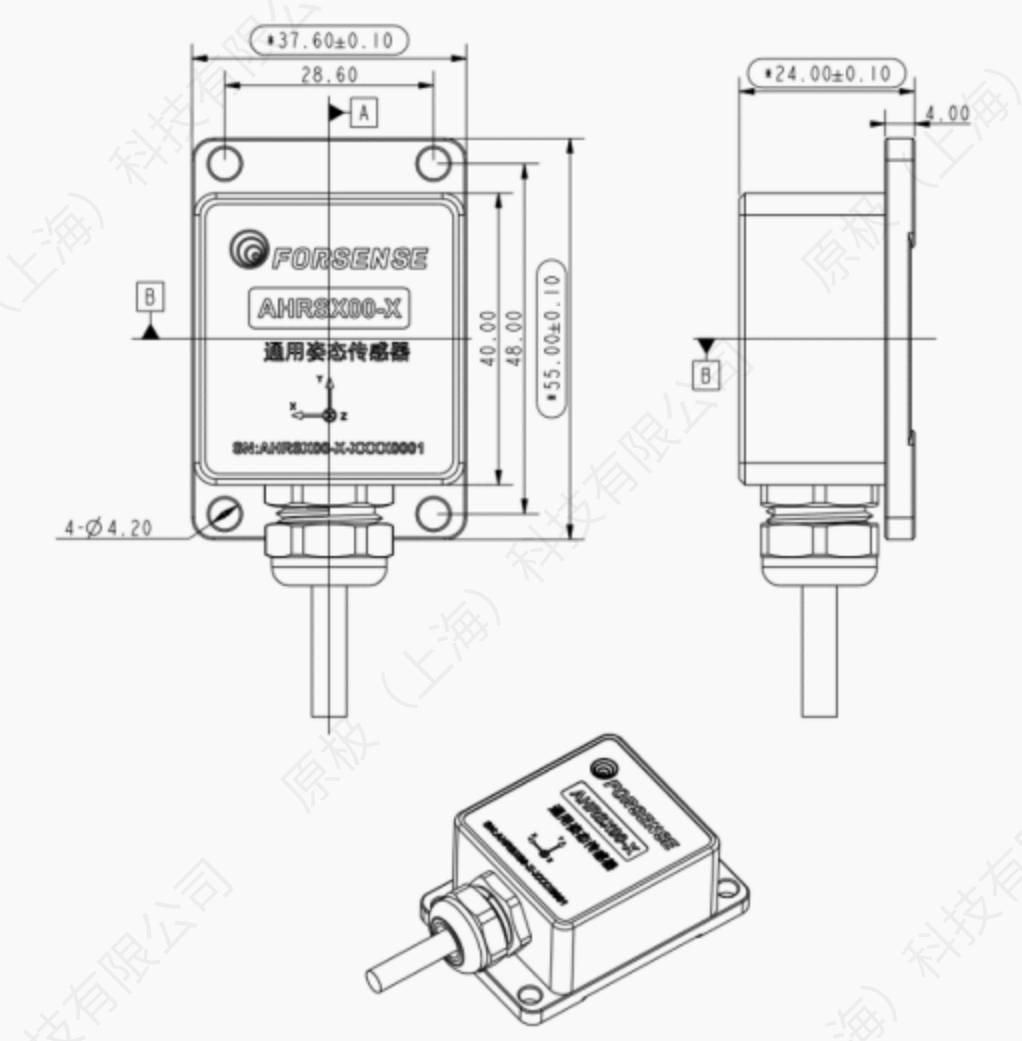
Table 1 Model definitions



name	Version type	Meaning	Maximum update rate supported
AHRS400	A	CAN version	200hz
	B	RS-485 version	400hz
	C	TTL version	1000hz
	D	RS-232 version	400hz
AHRS401	A	Single connector CAN version	200hz
AHRS402	A	Double connector CAN version	200hz

3 Form structure

Figure 1 AHRS400-X outline structure



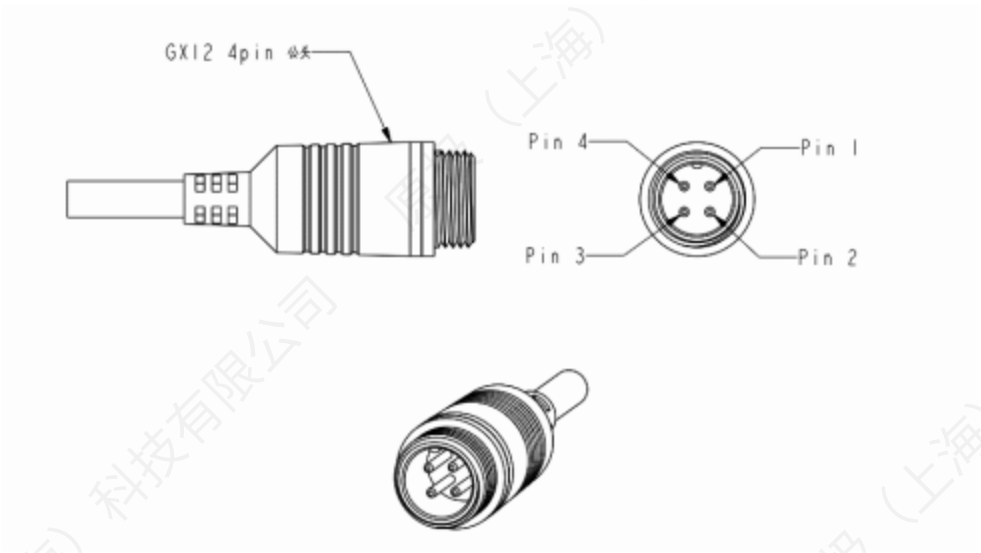
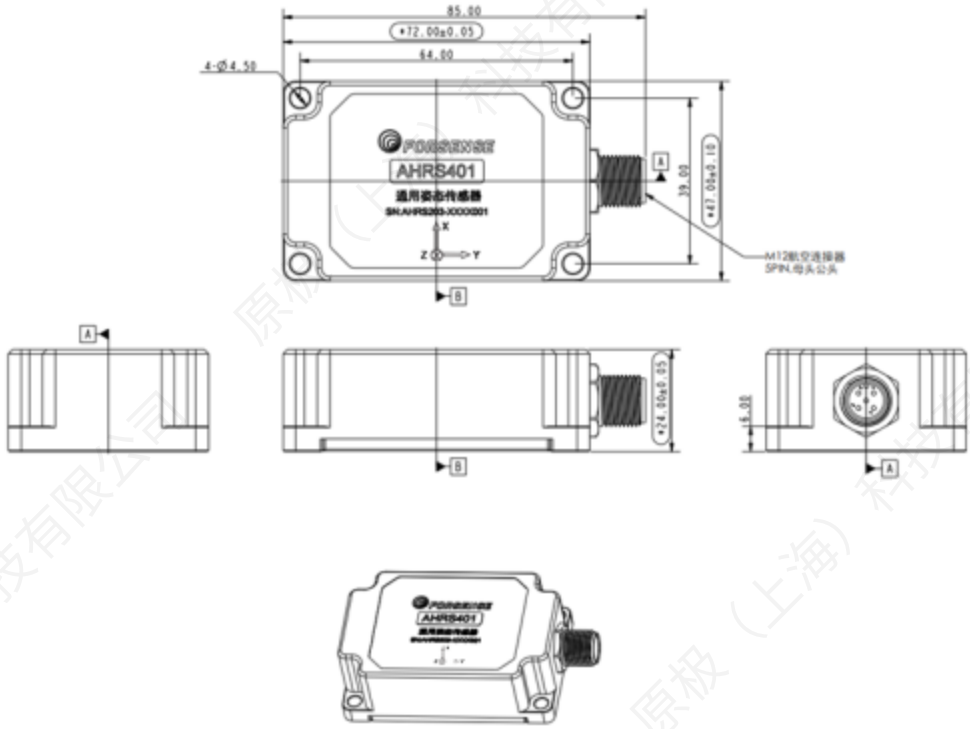
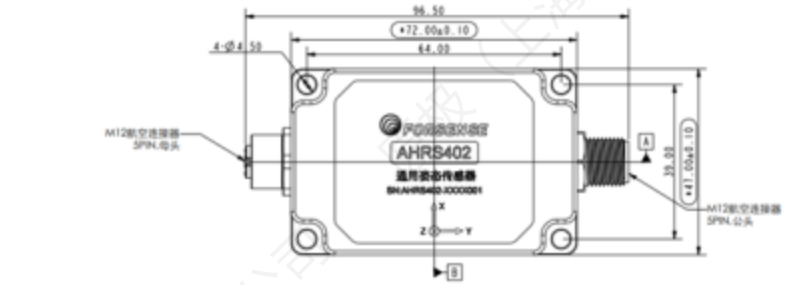
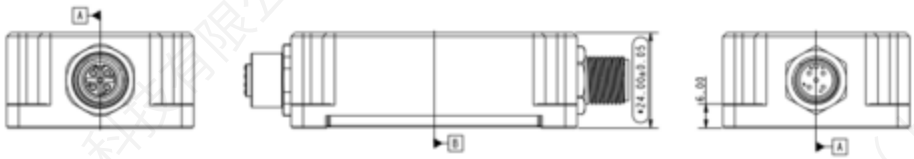


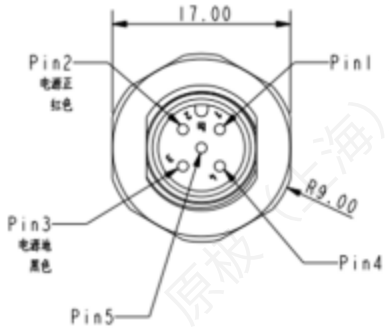
Figure 2 AHRS40X-A outline structure

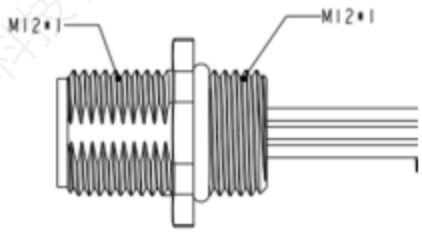


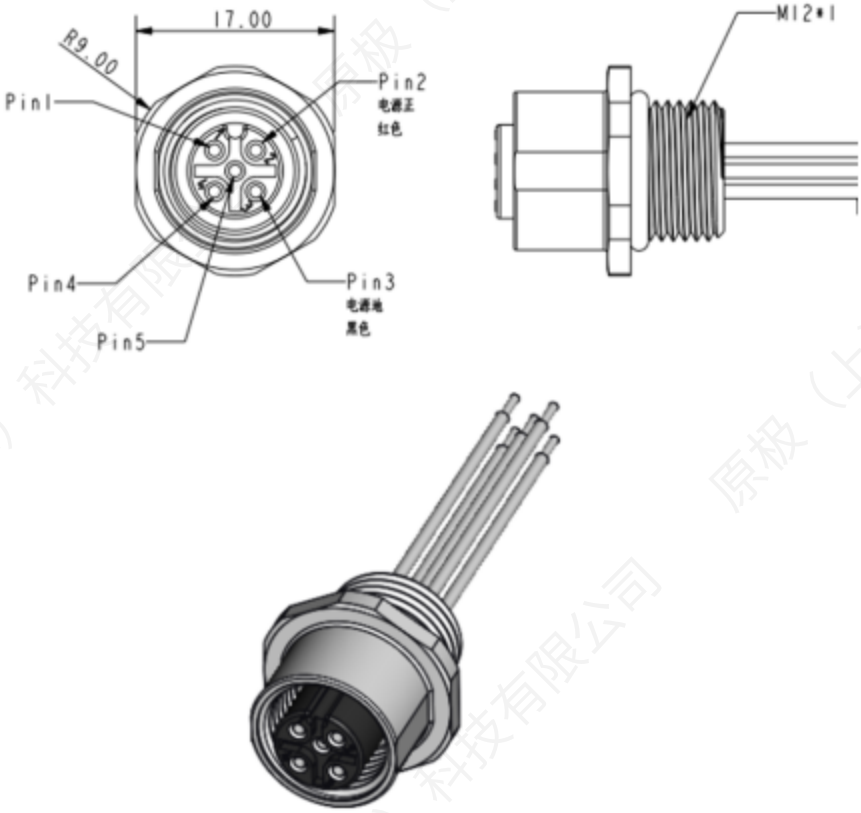

96.50
φ72.00±0.10
64.00
4-Ø4.50
AHRS402
M12航空连接器
5PIN.母头
M12航空连接器
5PIN.公头
35.00
φ41.00±0.10
A
B
X
Z
Y


A
B
A
φ24.00±0.05
6.00


AHRS402


17.00
Pin2
电源正
红色
Pin1
R9.00
Pin3
电源地
黑色
Pin4
Pin5


M12*1
M12*1



4. Electrical characteristics

4.1 Maximum tolerance value

Table 2 Maximum absolute rating

Parameters	symbol	Range	Units
Supply voltage	VCC	9 to 32	V
Power source	GND	-	-
Operating Temperature (Tot)	Tot	-40 to 85	℃
Storage temperature	Tstg	-40 to 85	℃

4.2 Working Conditions

Table 3 Working conditions

Parameter	Symbols	Minimum value	Typical value	Maximum value	Units

Supply voltage	VCC	.9	12	32	V
VCC maximum ripple	Vrpp	0		40	mV
AHRS400-A power consumption	P		0.36		W
AHRS400-B power consumption	P		0.3		W
AHRS400-C power consumption	P		0.2		W
AHRS400-D power consumption	P		0.24		W
AHRS401-A power consumption	P		0.36		W
AHRS402-A power consumption	P		0.36		W
Operating Temperature (Tot)	Tot	-40		85	℃
Storage temperature	Tstg	-40		85	℃

4.3 Interface Definition

Table 4 AHRS400-A interface definition

PIN	Colors	Definition	Description
1	red	VIN	9-32V DC input
2	black	GND	Ground (GND)
3	green	CAN_H	CAN_BUS
4	white	CAN_L	

Note: CAN communication baud rate is 500KHz, built-in matching resistance 120 ohms;

Table 5 AHRS400-B interface definition

PIN	Colors	Definition	Description
1	red	VIN	9-32V DC input
2	black	GND	Ground (GND)
3	green	DATA A	RS_485
4	white	DATA B	

Note: Built-in matching resistance 120 OHms;

Table 6 AHRS400-C interface definition

PIN	Colors	Definition	Description
1	red	VIN	9-32V DC input
2	black	GND	Ground (GND)
3	green	RXD	LVTTL
4	white	TXD	

Table 7 AHRS400-D interface definitions

PIN	Colors	Definition	Description
1	red	VIN	9-32V DC input
2	black	GND	electrically
3	green	RXD	RS232
4	white	TXD	

Table 8 AHRS40X-A interface definitions

PIN	Colors	Definition	Description
1	Shield	PE	Protected area
2	red	VIN	9-32V DC input
3	black	GND	Power ground

4	green	CAN_H	CAN_BUS
5	white	CAN_L	

Note: CAN communication baud rate of 500KHz, built-in matching resistance of 120 Ohms

5 Upgrade the function

5.1 CAN version firmware upgrade

Connect the computer using the attachment USB to CAN module. Open the Forsense IMU to test the Upper computer software -- select the corresponding serial port number -- select firmware upgrade -- Open the firmware -- select CAN interface upgrade -- set the upgraded firmware baud rate -- click Automatic upgrade.

Figure 2 Upgrade interface of Upper computer software of CAN version

5.2 Firmware upgrade of RS-485/RS-232/TTL version

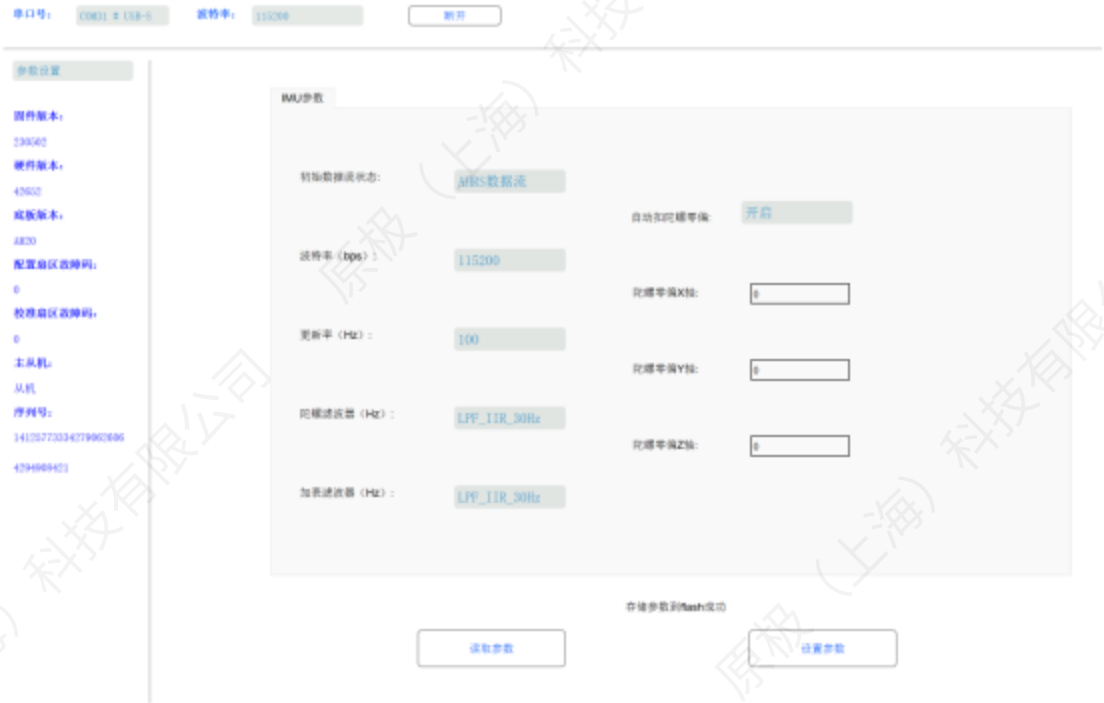
Test the Upper computer software using the Forsense IMU -- select Firmware upgrade -- Open firmware -- click Automatic Upgrade.

Figure 3 Upgrade interface of the Upper computer software of the RS-485/RS-232/TTL version

6. User parameters function

Use the primitive IMU to test the upper computer, the user can configure the update rate and filter equivalent;

Figure 4 User parameter configuration interface



7. Communication protocol

7.1 CAN communication protocol

Example of CAN host read driver based on STM32:

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

7.1.1 Communication parameters

Interface form: CAN, standard frame

CAN rate: 250Kbps~1Mbps (configurable)

7.1.2 Standard frame format

Table 8 CAN Standard Frame Format 101

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

Table 9 CAN standard frame format 102

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

Table 10 CAN Standard Frame Format 103

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

Table 11 CAN Standard Frame Format 104

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

Table 12 CAN Standard Frame Format 105

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

Note 1: Attitude Angle, gyro, accelerometer data is expressed as float, temperature, meter value data is expressed as int16

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

7.1.3 CAN Parameter Configuration

7.1.3.1 Configuring the CAN Baud Rate

Configure the CAN baud rate and send instructions:

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

The IMU replies as follows:

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

To query the CAN baud rate, send instructions:

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

The IMU replies as follows:

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

Where:

XX=01 baud rate is 250Kbps

XX=02 baud rate is 500Kbps

XX=03 baud rate is 1000Kbps

7.1.3.2 Configuring the Node ID

The default node is 100, set the node ID to 0X0102, and configure the instructions:

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

The IMU replies as follows:

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

7.1.3.3 Querying the version number

Send instructions:

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

The IMU replies as follows:

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

The version number is :0X0003120E, that is, firmware version number: 201230

7.1.3.4 Checking Terminal Resistance Settings

Remove the terminal resistor and send configuration instructions:

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

The IMU replies as follows:

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

Add terminal resistors and send configuration instructions:

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

The IMU replies as follows:

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

7.1.3.5 Setting the output frequency

Set the output frequency and send instructions:

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

The IMU replies as follows:

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

Query the output frequency and send instructions:

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

The IMU responds as follows:

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

Where:

XX=01 The output frequency is 1HZ

XX=02 The output frequency is 10HZ

XX=03 The output frequency is 50HZ

XX=04 The output frequency is 100HZ

XX=05 The output frequency is 200HZ

7.1.3.6 Check/set roll pitch inversion

To set the roll pitch reversal:

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

IMU answer instruction:

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

Query roll pitch to take inverse state:

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

IMU answer instruction:

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

Where:

XXXX=0X00 Roll pitch is not inverted

XXXX=0X01 Roll backwards and pitch is not reversed

XXXX=0X10 Roll is not reversed, pitch is reversed

XXXX=0X11 Roll and pitch are inverted

7.1.3.7 Check/set the filter cutoff frequency

To set the filter cutoff frequency:

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

IMU answer instruction:

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

Query the filter cutoff frequency:

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

IMU answer instruction:

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

Where:

XXXX=0X44 Cut-off frequency 10HZ

XXXX=0X66 Cut-off frequency 20HZ

XXXX=0XAA Cut-off frequency 40HZ

XXXX=0XBB Cutoff frequency 47HZ

7.1.3.8 Check/set the coordinate system

To set the coordinate system:

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

The IMU replies as follows:

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

To query the coordinate system:

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

The IMU replies as follows:

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

Where:

XXXX=0X65 Default orientation

Refer to section 7.2.9 of the manual for specific orientation Settings

7.1.3.9 Turn off/Subtract attitude Angle

Set off/deduct attitude Angle or deduct attitude Angle:

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

The IMU replies as follows:

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

To check whether the attitude Angle Settings are deducted:

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

The IMU replies as follows:

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

Where:

XXXX=0X01 minus attitude Angle

XXXX=0X00 No attitude Angle is deducted

7.1.3.10 Saving Commands

Send instructions:

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

The IMU responds as follows:

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

The storage takes time. The packets are returned after the storage is successful. After the storage is successful, the restart takes effect

7.2 Serial Port Communication Protocol

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

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

The serial port communication supports two modes: Stream Mode and Command Mode. The IMU enters the corresponding mode according to the mode value configured by parameters after the initialization is complete.

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

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

the IMU can also be configured.

7.2.1 Parameters of serial port interface

Table 13 Serial port parameters

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

7.2.2 Packet Format

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

Table 14 IMU output and user input data structures

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

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

last

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

7.2.3 Common AT commands

7.2.3.1 Stop the current data stream output

Instruction: AT+SETNO\r\n
Answer: OK\r\n
You can stop the current data stream (do not change the data stream parameters), output OK indicates that you can proceed to the next operation.
If there is no response, you can continue to send AT\r\nAT+SETNO\r\n command until the output is OK.
Restore data stream output:
Instruction: AT+SETNO\r\n
Answer: OK\r\n

7.2.3.2 Query version number

Instruction: AT+VERSION\r\n
Answer: SW_VERSION Firmware version
HW_VERSION Hardware version
BOARD_VERSION Backboard version
OK

7.2.3.3 Querying User Parameters

Instruction: AT+CONFIG\r\n
Answer: BAUD_RATE Baud rate of the current serial port
ORIENT current coordinate system
IMU_ODR Output frequency of the current IMU
STREAM_MODE1 Stream mode of serial port 1
STREAM_MODE2 Stream mode of serial port 2
STREAM_MODE3 Stream mode of serial port 3
LP_CONFIG_REG Filtering of the current IMU
OK

7.2.3.4 Setting and Querying the ODR

Example: Set the output frequency ODR to 50hz
Instruction: AT+SET_ODR=50
Response: IMU_ODR:50
OK
query the ODR instruction of the IMU
: AT+GET_ODR
Answer: IMU_ODR:
OK

7.2.3.5 Setting and querying the coordinate system

Example: Set the IMU coordinate system to top right front
Instruction: AT+SET_ORIENT=101\r\n
Answer: orientation:101
OK
Query the IMU current coordinate system
Instruction: AT+GET_ORIENT\r\n
Answer: orientation:
OK

7.2.3.6 Check/set roll pitch inversion

AT+SET_ATT_ORIENTATION=00\r\n Roll pitch does not invert
AT+SET_ATT_ORIENTATION=01\r\n roll reverse, not reverse pitch
AT+SET_ATT_ORIENTATION=10\r\n roll is not reversed, pitch is reversed
AT+SET_ATT_ORIENTATION=11\r\n roll and pitch are reversed

7.2.3.7 Set and query the baud rate

Example: Set the baud rate of the IMU to 115200
Instruction: AT+SET_BAUD=115200\r\n
Answer: OK
Query the current baud rate of IMU
Instruction: AT+GET_BAUD\r\n
Answer: BAUD_RATE:
OK

7.2.3.8 Setting and querying filters

Example: Set the filter of the IMU to 20hz
Instruction: AT+SET_LPF=102\r\n
Answer: LP_CONFIG_REG:102
OK
Query the IMU current filter
Instruction: AT+GET_LPF\r\n
Answer: LP_CONFIG_REG:
OK

Table 15 Low-pass filtering values and AT instruction corresponding values

Serial Number	IMU low-pass filter value	The value corresponding to the AT instruction
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

7.2.3.9 Save parameters

Instruction: AT+SAVE\r\n
Answer: OK

7.2.4 Data Stream Frame -- AHRS data

Table 16 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 200Hz@115200bps

Table 17 Serial port 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 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: 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 18 Serial port A1 gets AHRS data stream

Description	Original value	Analytic value	Description	Raw Value	Analytic value
ID	0200	02	Y-axis acceleration	BC74133C	0.009 g
Length	2C00	44	Z-axis acceleration	60E580BF	1.007 g
Time scale	6D891605	85363053	X axis Angular velocity	EC5138BD	0.045 ° / s
Pitch angle	8FC26540	3.59 °	Y-axis Angular velocity	0AD7A3BB	0.005 ° / s
Roll angle	14AE07BF	0.53 °	Z axis Angular velocity	CDCCCCBC	0.025 ° / s

Yaw angle	5C0FB243	356.12 °	imu chip temperature	D7A3EE41	29.83 ℃
X-axis acceleration	2506813D	0.063 g	crc32 Check	0CBF8480	2156183308

7.2.5 Command Mode GET Output -- System status

Table 19 COM system status data format

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

Note 1: Depending on the IMU model, the length of this frame will vary, all represent the length of S1, need to be confirmed according to the imu model.

Table 20 Load data format of COM S1

offset	Name	Data type	Description
0	Software_ver	uint32	Software version number
4	Hardware_ver	uint32	Hardware version number
8	rev	uint16	Reserved bytes
10	sn0	uint32	First SN number
14	sn1	uint32	Second SN
18	sn2	uint32	Third SN
22	Board_version	uint32	Baseboard version number
26	Rev[16]	Uint8	All that follows is reserved bytes

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

For example, obtain the IMU status
Enter 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 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 the response data, the software version number 211231(1F 39 03 00) and the hardware version number 94053(65 6F 01 00) are parsed.

7.2.6 Command Mode GET output -- Read the Parameter

Table 21 COM Parameter Input data format

	Frame header	Frame header	ID	length	payload	Frame tail

Data type	uint8	uint8	uint16	uint16	P1	uint32
Coding	0x55	0xAA	0x0006	0x0018		crc32

Table 22 COM Parameter output data format

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

Note 1: The IMU turns the data stream off when reading a parameter

Table 23 Serial port P1 load data format

offset	Name	Data type	Description
0	Param1	float	Parameters obtained (input data can be ignored)
4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the parameter index
12	Param4	uint32	Reserved, the default value is 0
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Keep, default is 0

Table 24 Index table of COM P1 load parameters

Param3	Param1	Units
3	The COM outputs the baud rate. The following baud rates are supported 115200,230400,460800,921600,1500000	bps
4	Coordinate system orientation (see Table 30 Coordinate System Orientation correspondence table)	
8	X-axis gyro zero bias calibration results, GYRO_X_OFF	°/s
9	Y-axis gyro zero bias calibration results, GYRO_Y_OFF	°/s
10	Z-axis gyro zero bias calibration results, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, defines the same SPI FILTER_CTRL table	

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 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).

7.2.7 Command Mode SET command

Table 25 COM Input command format

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

Note 1: For details about the relationship between CMD and R1, see the R1 load Parameter index table

Table 26 COM R1 load data format

offset	Name	Data type	Description
0	Param1	float	Set Parameter
4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the Parameter index
12	Param4	uint32	Reserved, the default value is 0

Table 27 Index of Parameter of the COM R1 load

CMD	Param1	Param3	**Description**
1	0	0	Trigger to get system status data once
2	0	0	Trigger to obtain AHRS data once
3	<mode>	0	< 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 Parameter, value is the index of the Parameter to be read, that is, P1.index, see the COM response output - Parameter read For example, if you want to read AHRS output frequency (ODR), set value=21 For example, to read the baud rate of the COM, set the value to 3 For example, if you want to read the internal filter, set value=31 For example, if you want to read the coordinate system orientation, set value=4
9	0	0	Perform a software restart
14	<value>	3	To set the baud rate of the output of the COM, the valid value in bps value is: 115200,230400,460800,921600,1500000 If value is other values, the default value is 115200bps The baud rate Parameter takes effect only after the system restarts. Procedure for setting the power-off: Set the baud rate, save 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 For other output frequencies, contact Forsense technology
14	<value>	31	Internal filter configuration, defined as SPI Accelerometer and gyroscope filter configuration, default 0xBB, that is, 47Hz

14	<value>	4	Set the orientation of the IMU coordinate system. The value ranges from 101 to 124. See Table 30 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: Corresponding commands can be generated and sent using the Upper computer software command generator function. For the usage method, see the Upper computer software Usage section of this manual
For example, to enable AHRS output:
Enter 3 in CMD ID and 1 in Parameter 1. The generated hexadecimal array can be filled into the COM assistant or program array and sent to the IMU.

7.2.8 Command Mode Output -- User Command Response

Table 28 Setting Parameter COM response data format

	Frame header	Frame header	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 29 Reserved Parameter COM response data format

	Frame header	Frame header	ID	length	ACK	result	Frame Tail

Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x753D	0x0004	0x0005	0x01	crc32

Table 30 Data format of COM user command response

	Frame header	Frame header	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,
47,00,00,00,00,03,00,00,00,00,00,00,00,00,00,00,00,00,00,00,56,2 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 00 0A 2B 2C 8D
Response data: AA 55 3D 75 04 00 34 75 15 00 70 2D B2 48

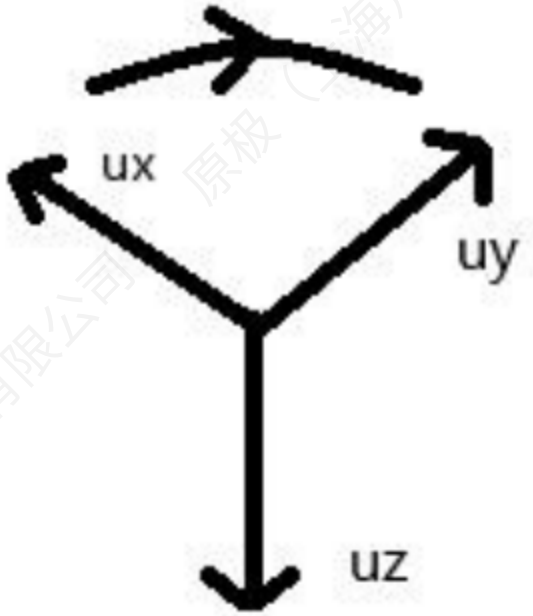
Save the current parameter to FLASH
Enter data: 55 AA 05 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 C9 2F E6 32
Response data: AA 55 3D 75 04 00 05 00 01 00 5A CF B1 7C

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 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

7.2.9 Coordinate system setting function

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

Figure 5 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:

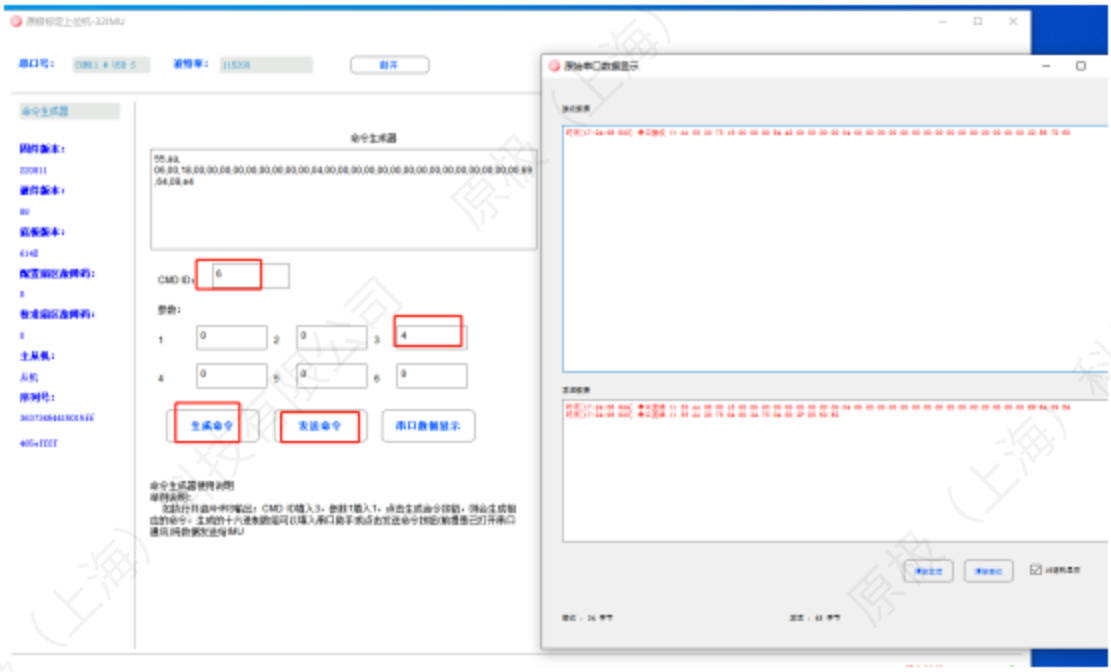
The orientation of the coordinate system in Table 31 corresponds to the table

Orientation (value)	XAxis	YAXis	ZAxis	Instructions
101	+Ux	+Uy	+Uz	Default orientation
102	-Ux	-Uy	+Uz	
103	-Uy	+Ux	+Uz	
104	+Uy	-Ux	+Uz	
105	-Ux	+Uy	-Uz	
106	+Ux	-Uy	-Uz	
107	+Uy	+Ux	-Uz	
108	-Uy	-Ux	-Uz	
109	-Uz	+Uy	+Ux	
110	+Uz	-Uy	+Ux	
111	+Uy	+Uz	+Ux	
112	-Uy	-Uz	+Ux	

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

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

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



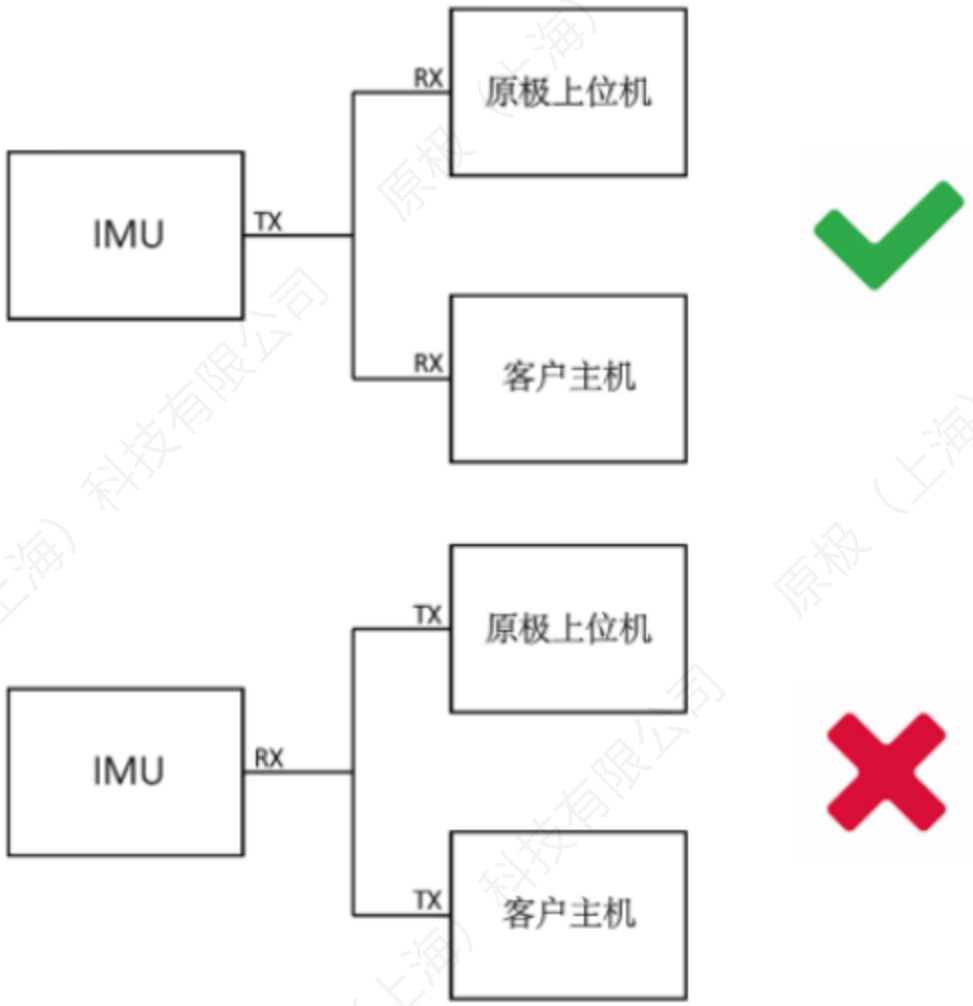
Example: Set the coordinate system to face 115
Data input: 55, aa, 0 e, 00,18,00,00,00, e6,
42,00,00,00,00,04,00,00,00,00,00,00,00,00,00,00, 00,00,00,00,46,6 a, 4 e, 86
Response data: AA 55 3D 75 04 00 34 75 04 00 60 0E 6B 1B
Refer to Table 27 to parse the parameter index as 04, and the setting is successful

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 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 00 00 00 00 00 00 00 00 00 B2 2F 2D 4E
According to Table 21 and Table 22, the parsing results in 115 for parameter 1 (float) and 04 for parameter 3. That is, the coordinate system is 115 orientation

7.2.10 FAQs about COM Connection

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 6 Schematic diagram of COM connection

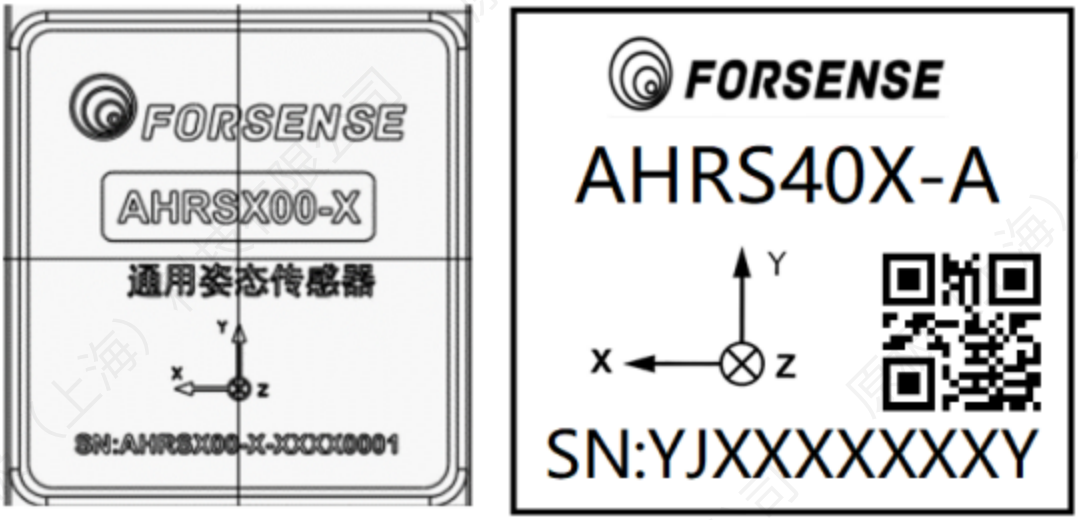


注：IMU TX 可接多路 RX，RX 不可接多路 TX；
IMU串口不可同时连接客户主机和原极上位机；
IMU可以预留另外一路串口专门连接原极上位机。

2) The version number cannot be obtained
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.

8. Coordinate system definition

Figure 7 Diagram of coordinate system



The product coordinate system uses the front-right-down (FRD) coordinate system, and the 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°.

FIG. 8 AHRS401 coordinate system diagram

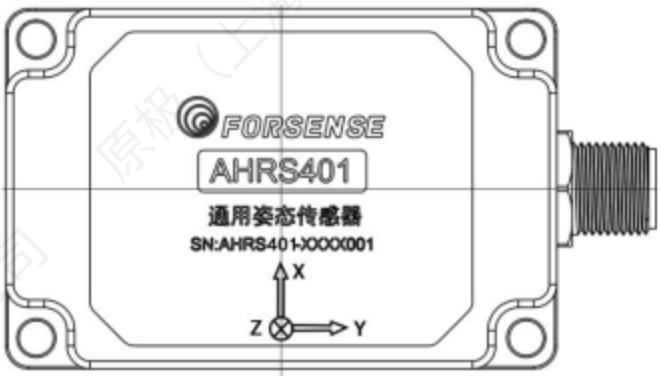


FIG. 9 Schematic diagram of AHRS402 coordinate system

CRC table lookup method calculation

It is recommended to refer directly to the example code.
Note 1: Data is transmitted in small-endian format, with low bytes first and high bytes last
Note 2: The initial value of crc32 is 1, and CRC calculations do not include all the data in this frame itself

```
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;
 }
```

10. Optional accessories

 USB to CAN module	 485 COM
 232 COM	 TTL COM
 Power signal pair cable	

11 Update the record

Versions	Dates	Status/Comments
Version 1.0	2023.07.18	First issue
Version 1.1	2023.10.07	Update coordinate system definition
Version 1.2	2023.12.14	Add attachments
Version 1.3	2024.03.18	Add 401A&402A series
Version 1.4	2024.06.17	Added CAN Parameter instruction

Version 1.5	2024.08.15	Part AT instruction added