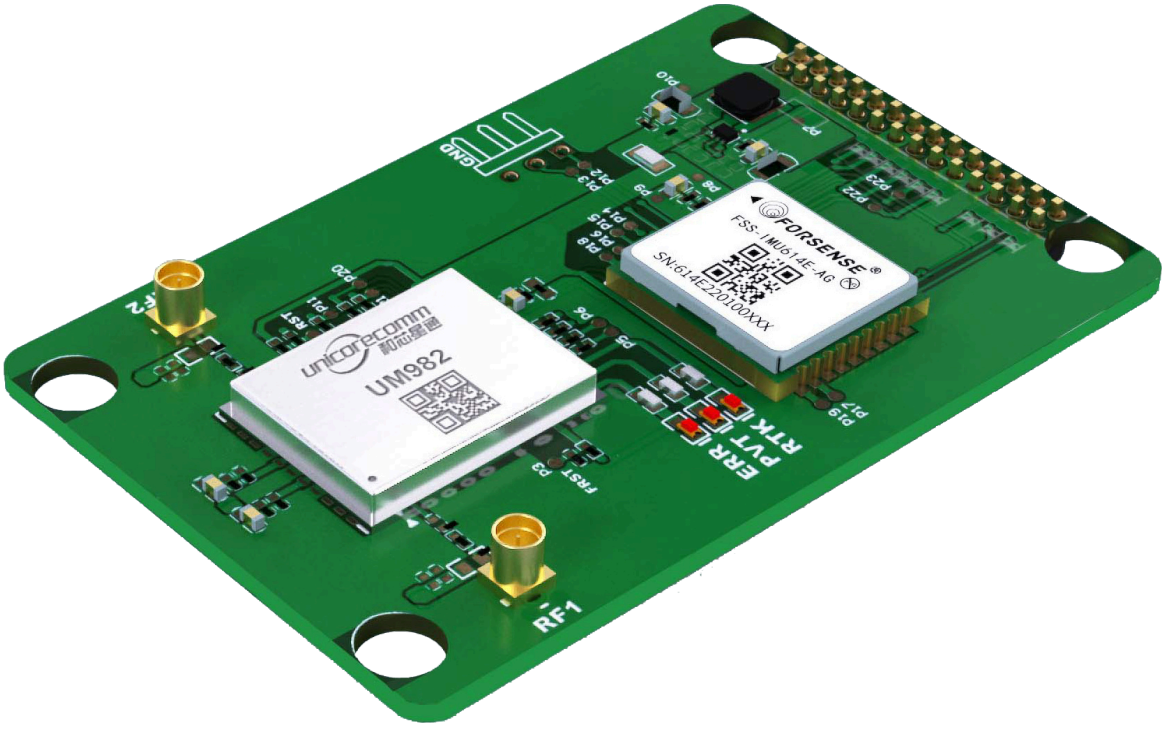
FORSENSE
原极科技

High-Precision GNSS

FS982-AG

Product manual



Forsense (Shanghai) Technology Co., Ltd

Please read this user manual carefully before using this product.

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1. Product Overview

1.1 Technical Specifications

Attitude Accuracy	**Roll/Pitch :<0.2° rms** **Heading: <0.3° rms (vehicle speed >1 km/h, Ackermann steering vehicle scenarios)**	
Update Rate	100hz	
Gyroscope Range	±500°/s	
Gyroscope Bias instability	4.0deg/h @1σ	
Accelerometer Range	±6g	
Accelerometer Bias instability	0.04mg @1σ	
Position Reckoning Accuracy	<2% @1σ (Vehicle scenario, Satellite signal loss 30s, no wheel speed sensor combination)	
RTK Metrics	positioning accuracy(RMS)	Single Point: 1.5m RTK: 1cm+1ppm
	Dual antenna Heading Accuracy (RMS)	0.1°/1m baseline
	velocity accuracy(RMS)	0.03m/s
	PPS Accuracy (RMS)	20ns
	Update Rate	20hz
	RTK initialize Time	<5s

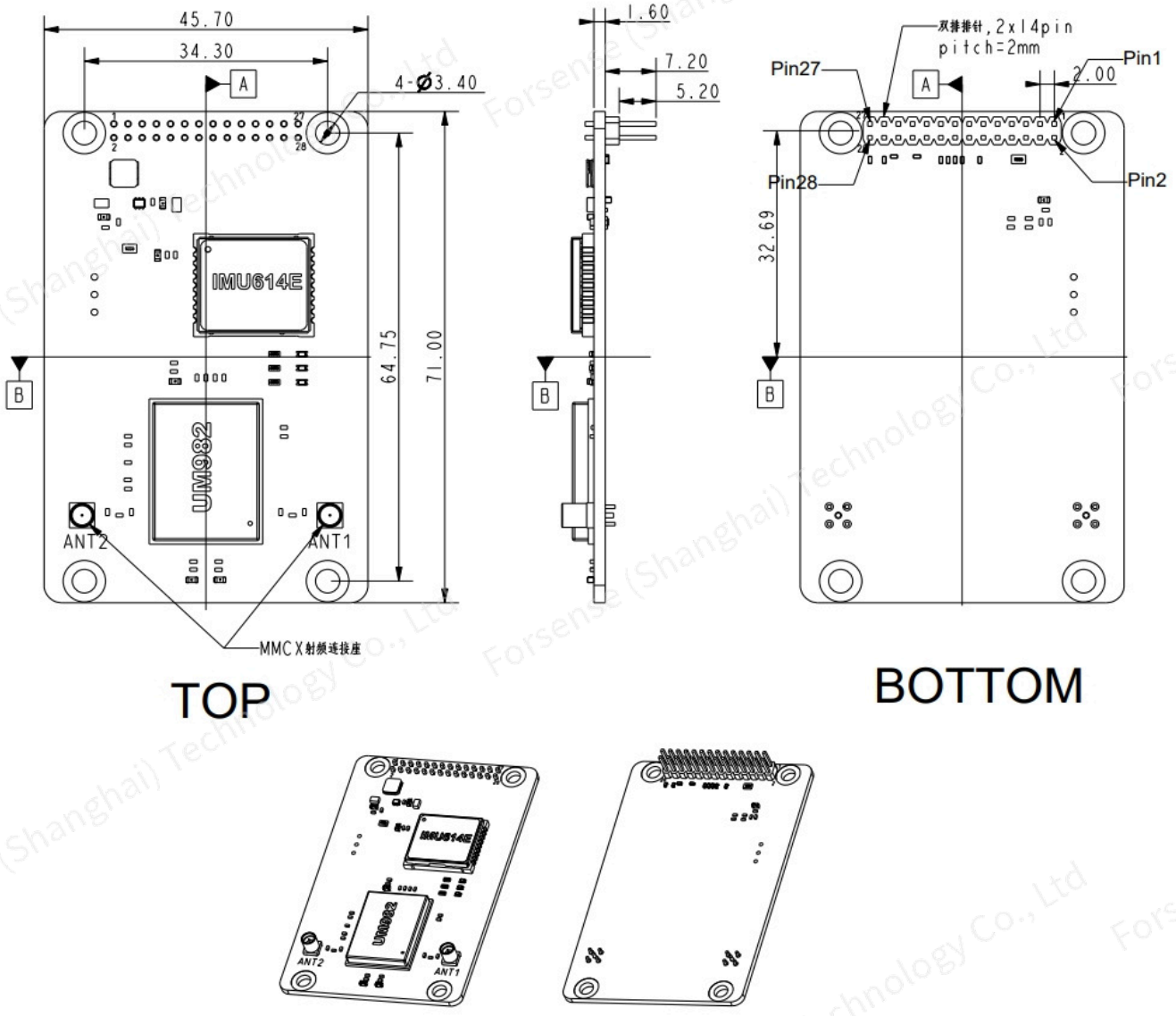
1.2 Board Overview

To address the requirements for precise and continuous positioning in lightly occluded scenarios such as orchards for agricultural autonomous driving, Forsense is based on the IMU614E-AG agricultural single antenna IMU modules, integratingAll Constellations,All Systems,the all-frequency high-precision positioning and orientation module UM982. A board-level Integrated Navigation product FS982-AG specifically designed for agricultural applications has been developed, featuring built-in Forsense multi-model intelligent position fusion algorithms tailored for vehicle-mounted scenarios. This solution provides agricultural autonomous driving customers with high-precision vehicle attitude, heading, and continuous positioning and speed measurement even under occlusion and interference conditions. It supports reliable full-scenario operation of agricultural autonomous driving and enhances the the terminal application experience of autonomous driving equipment.

2. Hardware Composition

2.1 Mechanical Dimensions

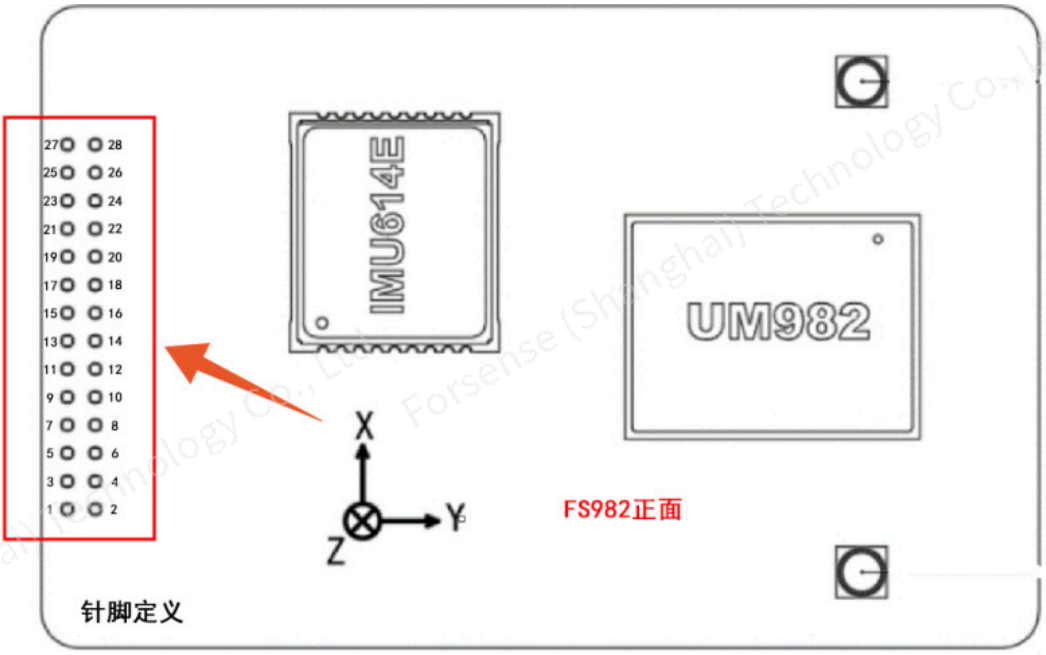
Figure 1 Mechanical Dimensions (Unit: mm)



2.2 Connector and Pin Definitions

Except for the ANT1 and ANT2 MMCX interfaces, FS982-AG provides the following 28-pin Cvilux dual-row header: pin pitch: 2.0 mm; pin length: 3.9 mm; socket thickness: 2.0 mm.

Figure 2 Schematic of Connector PIN Pin



2.3 Pin Function Description

Table 1 Pin Description

Pin	Signal	Input/Output	Description	Remarks
1	RSV	-	Retain	-
2	RSV	-	Retain	-
3	RSV	-	Retain	-
4	RSV	-	Retain	-
5	RSV	-	Retain	-
6	VCC	Power	Power Input	5VDC
7	RSV	-	Reserved	-
8	RXD2_IMU	I	IMU Serial Port 2 Receive (For Firmware Update)	LVTTL power level
9	RSV	-	Reserved	-
10	RSV	-	Reserved	-
11	RSV	-	Reserved	-
12	RSV	-	Reserved	-
13	TXD2_IMU	O	IMU Serial Port 2 Send(For Firmware Update)	LVTTL power level
14	GND	Power	Numbers and Ground (GND)	
15	TXD1_IMU	O	IMU Serial Port 1 Send(User Use)	LVTTL power level
16	RXD1_IMU	I	IMU Serial Port 1 Receive(User Use)	LVTTL power level
17	GND	Power	Numbers and Ground (GND)	
18	TX2_982	O	982 Serial Port 2 Send	LVTTL power level

19	RX2_982	I	982 Serial Port 2 Receive	LVTTL power level
20	GND	Power	Numbers and Ground (GND)	
21	RSV	-	Reserved	-
22	GND	Power	Numbers and Ground (GND)	
23	PPS	O	Time Synchronization Signal	LVTTL power level
24	RSV	-	Reserved	-
25	RSV	-	Reserved	-
26	CAN_TX	O		LVTTL power level
27	RSV	-	Reserved	-
28	CAN_RX	I		LVTTL power level

2.4 Electrical Characteristics

Table 2 Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit
supply voltage(VCC)	Vcc	-0.3	5.5	V
Input Pin Voltage (Vin)	Vin	-0.3	3.3	V
Maximum VCC Ripple	Vrpp	0	40	mV
Input Pin Voltage (Vin) (All Other Pins Except Those Mentioned Above)	Vin	-0.3	3.6	V
Primary antenna RF Input Power	ANT1_IN input power		±15	dBm
From Antenna RF Input Power	ANT2_IN input power		±15	dBm
Maximum ESD Stress Level	VESD(HBM)		±2000V	V

2.5 Operating Conditions

Table 3 Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
supply voltage(VCC)		4.75	5	5.25	V	
Power-on Impulse Current	Iccp			10	A	Vcc=5V
Input Pin Low Level	Vin_low_1	-0.3		0.9	V	
Input Pin High Level	Vin_high_1	2.4		3.6	V	
Output Pin Low power level	Vout_low	0		0.45	V	Iout=4mA
Output Pin High power level	Vout_high	2.85		3.3	V	Iout=4mA
Optimal Input Gain	Gant	20		36	dB	
Power Consumption	P		1.15		W	

2.6 Physical Characteristics

Table 4 Physical Characteristics

Working Temperature	**-40℃~+85℃**
Storage Temperature (Tstg)	-55℃~+95℃
Humidity	95%non-condensing

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3. Hardware Integration Guide

3.1 Design Considerations

- To ensure proper operation of FS982-AG, the following signals must be correctly connected:
- The module VCC power-on exhibits good monotonicity, and the initial power level is below 0.4V; undershoot and ringing are guaranteed within 5% of VCC
- Use VCC Pin to provide a reliable power supply, and ground all board GND Pin pins
- ANT1, ANT2 MMCX interface provides antenna biasing. For the module antenna port with no antenna connected, test with a multimeter: under no-load conditions, the voltage provided is DC4.8~5.4V. When the module RF Port is connected to an antenna, at room temperature with operating current between 30~100mA, it can externally provide an antenna bias of DC4.6V ± 0.2V. Note that the line requires 50-ohm impedance matching
- Ensure IMU Serial Port 1 output; users need this Serial Port to receive IMU data
- Ensure IMU Serial Port 2 is connected to pads or connectors; users need this Serial Port for Firmware Update
- Ensure 982 Serial Port 2 output; users need this Serial Port to receive positioning information data
- Board reset Pin FRESET_N restores factory settings, while RESETIN performs a quick reset. Connect correctly to ensure reliable board reset
- To achieve good performance, special attention should be paid to the following items in the design:
- Power Supply: Good performance requires a stable power supply with low ripple. The ripple voltagepeak-to-peak valueshould preferably not exceed 50mVpp. It is recommended to use a power chip with an output current capability greater than 2A to supply the board. In addition to using an LDO to ensure clean power supply, the following should also be considered:
- - Widen power traces or use split copper planes for current transmission
- - Place the LDO as close to the board as possible in the layout
- - Avoid routing power traces near high-power components and high-inductance components such as magnetic coils
- Ensure the UART InterfaceUser Mastermatches the signal and baud rate of the FS982-AG board
- Keep antenna traces as short and smooth as possible; avoid sharp angles and pay attention to impedance matching
- Avoid routing traces directly underneath FS982-AG
- Keep the board away from high-temperature airflow

3.2 Pin Precautions

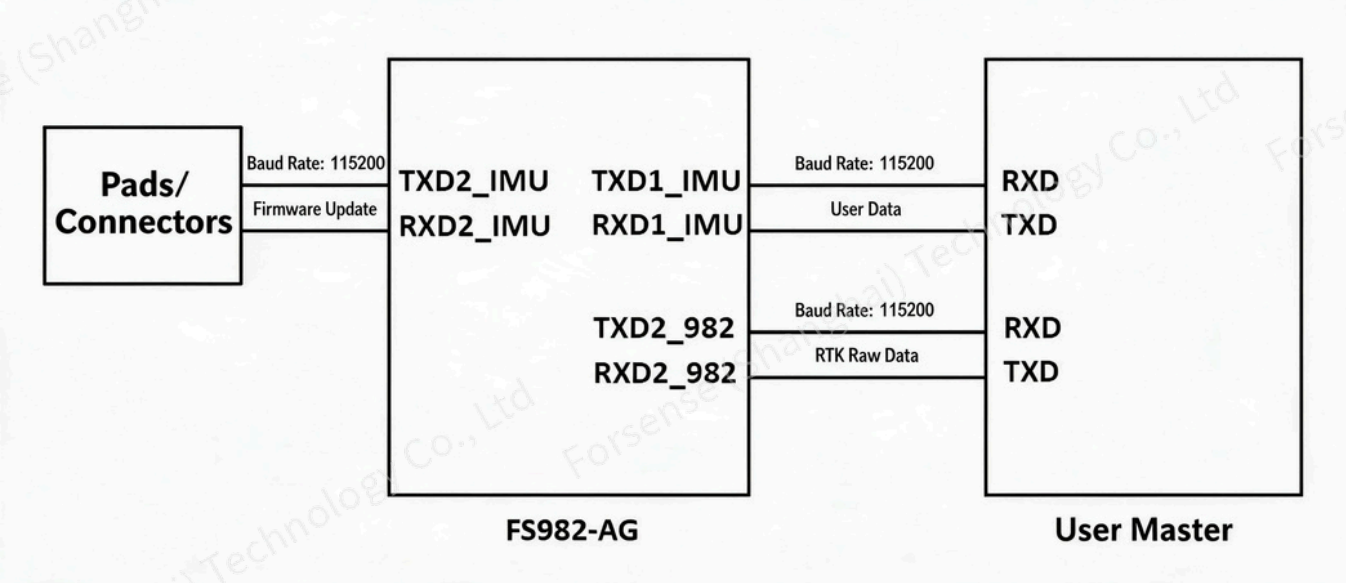
Table 5 Pin Precautions

Function	Pin	I/O	Description	Notes
Power Supply	VCC	Power Supply	Power Supply Source	Stable, clean power supply with low ripple; peak-to-peak ripple voltage preferably not exceeding 50mVpp
	ANT1/ANT2	Power Supply	Antenna Power Supply	active antenna provides power supply at the corresponding voltage. For the module antenna port, when no antenna is connected, test with a multimeter; under no-load conditions, the output voltage is DC4.8~5.4V. When the module RF Port is connected to an antenna, at room temperature and with a working current of 30~100mA, it can externally provide an antenna feed voltage of DC4.6V±0.2V.
	GND	Power Supply	Ground	Ground all GND signals of the board, Use large-area copper pour for grounding if possible.

UART	TXD1_IMU	O	IMU Serial Port 1 Transmit	IMU Serial Port 1 Output, must be connected to user Master
	RXD1_IMU	I	IMU Serial Port 1 Receive	
	TXD2_IMU	O	IMU Serial Port 2 Transmit (For Firmware Update)	IMU Serial Port 2 Output, must be connected to a pad or connector for Firmware Update
	RXD2_IMU	I	IMU Serial Port 2 Receive (For Firmware Update)	
	TXD2_982	O	982 Serial Port 2 Transmit	982 Serial Port 2 Output, must be connected to user Master
	RXD2_982	I	982 Serial Port 2 Receive	

3.3 Hardware Wiring Method

Figure 3 Hardware Wiring Method



3.4 Antenna

FS982-AG board antenna input: ANT1 and ANT2 MMCX interfaces provide antenna power. For ANT1 and ANT2 antenna ports without an antenna connected, a multimeter test shows no-load voltage of DC4.8~5.4V; when the module RF Port is connected to an antenna, at room temperature with operating current of 30~100mA, it can externally provide antenna power of DC4.6V±0.2V. When using active antenna on the FS982-AG board, note the 50-ohm impedance matching between the board and the antenna.

4. Usage Example

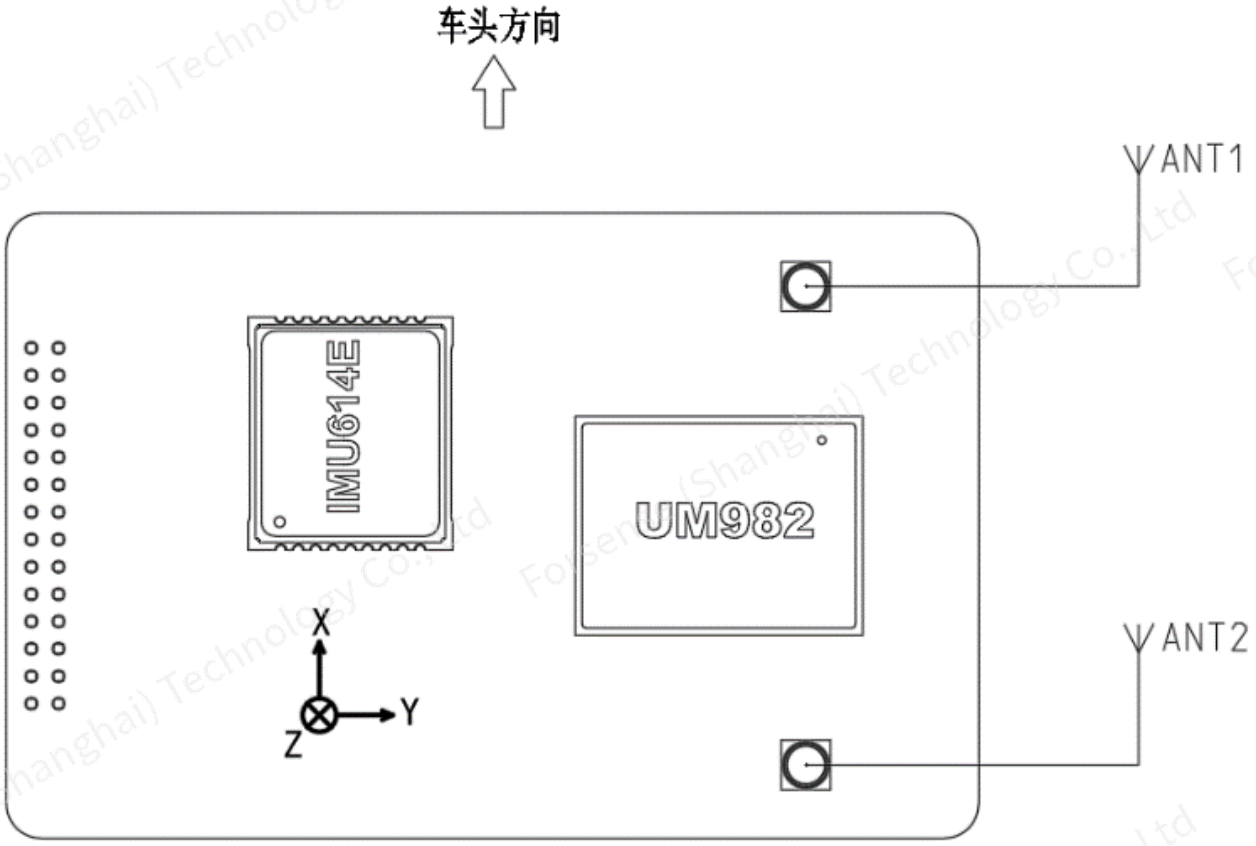
4.1 Device Installation

1. The module should be securely fixed to a rigid plane, avoiding installation in locations with high vibration.

2. The module's installation orientation should maintain the relationship described in the figure below relative to the vehicle's forward direction.

3. ANT1 is a Primary antenna (positioning antenna) RF connector, and ANT2 is a Secondary antenna (directional antenna) RF connector. The Dual antenna directional result of RTK board is the angle between the ray pointing from Primary antenna to Secondary antenna and geographic (true) north direction.

Figure4 Antenna Connection Diagram



Since there is no coordinate system marking on the module, the installation orientation can be confirmed by the triangular shape indicator on the IMU module, as shown in the figure below.

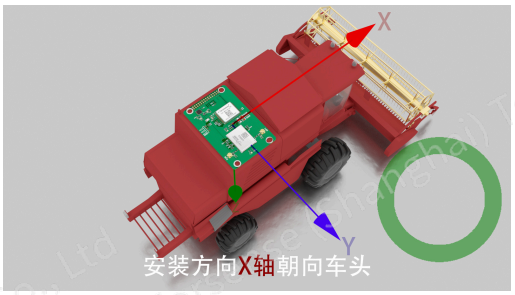
Figure5 Coordinate System Schematic



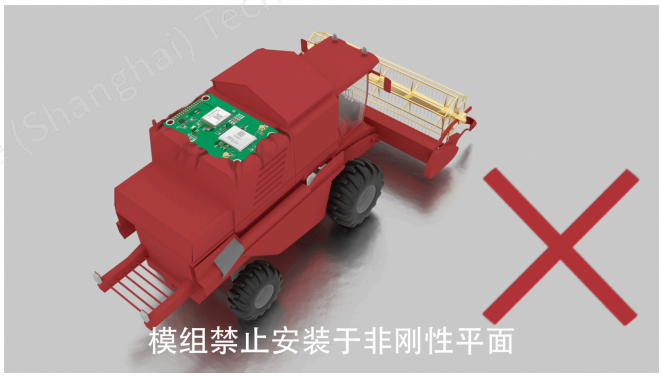
The correct installation diagram is shown below

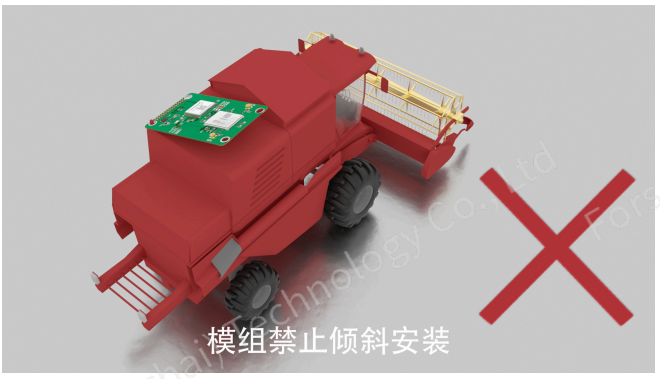
X-axis points towards the front of the vehicle

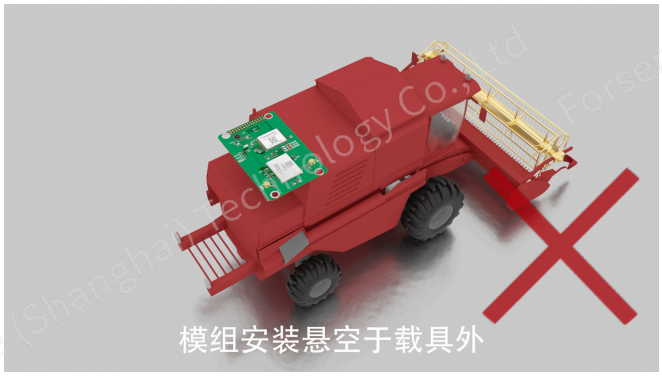
Figure6 Correct Installation Diagram



The following installation methods are allIncorrect Installation













Module Installation Precautions

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

Figure 7 Incorrect Installation Diagram



4.2 RTK Differential Data Import

Users must obtain the RTK GPGGA message via the RS232-RTK interface, log in to the network CORS account on Qianxun SI or Sixents Technology, and import differential data to enable RTK to enter the fixed solution state.

4.3 Parameter Configuration

4.3.1 Configure Primary antenna Lever Arm

For example, configure lever arm vector as X=0.5m,Y=-0.6m,Z=-1.0m

Command : AT+CLUB_VECTOR=0.5,-0.6,-1.0\r\n

Response : GPS_POS_X=0.5,GPS_POS_Y=-0.6,GPS_POS_Z=-1.0\r\n

Note: lever arm vector is the 3D vector (X,Y,Z) of the RTK Primary antenna phase center relative to the IMU phase center, in meters. Where,

In the front-right-down vehicle body coordinate system

If RTK Primary antenna is in front of the IMU, the value is positive; otherwise, it is negative;

If RTK Primary antenna is to the right of the IMU, the value is positive; otherwise, it is negative;

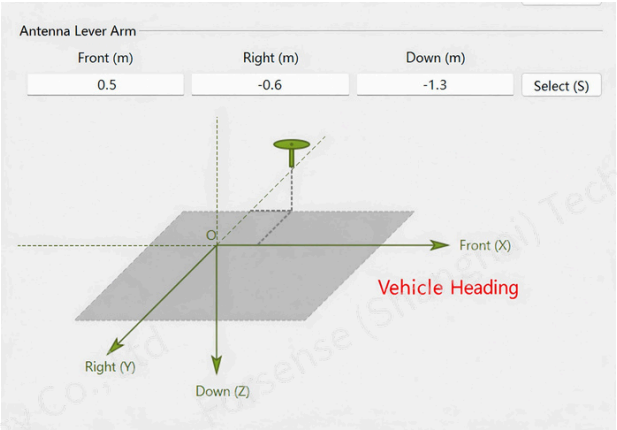
If the RTK Primary antenna is located above the IMU, it is**negative**, otherwise positive (the antenna is generally above the device).

The coordinate system diagram is shown below: (the label must face upward; if the IMU is not installed as shown in the figure, the installation orientation must be configured)

Figure8 Coordinate System Diagram



Figure9 Antenna Lever Arm Diagram



4.3.2 Configure Rear Axle Center Lever Arm

For example, configure lever arm vector as X=0.5m,Y=-0.6m,Z=1.0m

Command : AT+OD_VECTOR=0.5,-0.6,1.0

Response : OD_POS_X=0.5,OD_POS_Y=-0.6,OD_POS_Z=1.0\r\n

Note: lever arm vector is the 3D vector (X,Y,Z) of the rear axle center relative to the IMU phase center, in meters. Where,

In the front-right-down vehicle body coordinate system

If the rear axle center is in front of the IMU, the value is positive; otherwise, it is negative;

If the rear axle center is to the right of the IMU, the value is positive; otherwise, it is negative;

If the rear axle center is below the IMU, it is**positive**, otherwise negative (the rear axle center is generally below the device).

The coordinate system diagram is shown below: (the label must face upward; if the IMU is not installed as shown in the figure, the installation orientation must be configured)



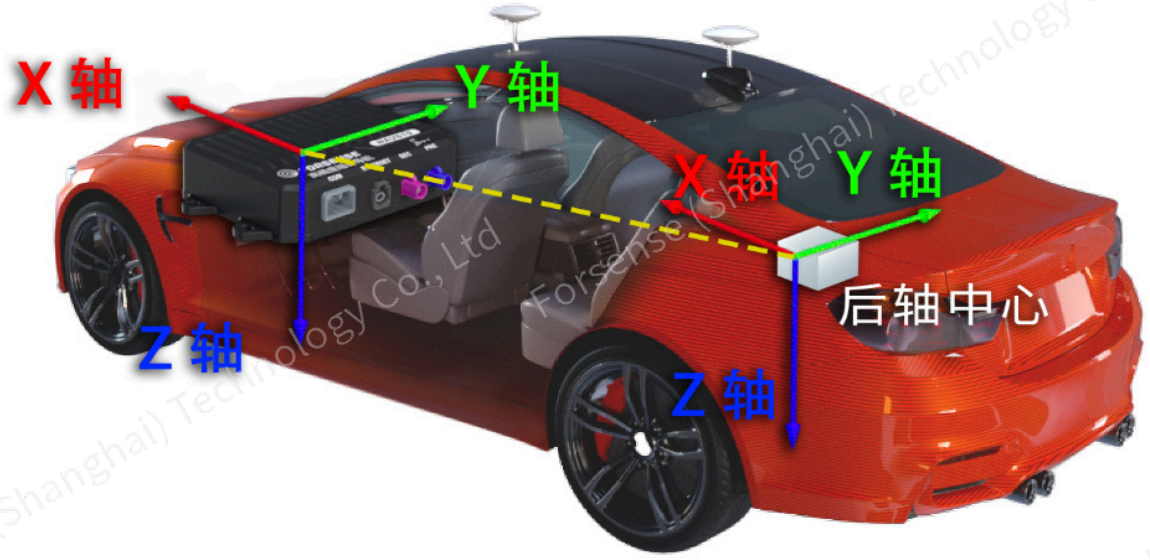


Figure 10 Coordinate System Diagram

4.3.3 Configure Vehicle Wheelbase

If the vehicle wheelbase is configured as 2 m, the configuration command is:

AT+WHEEL_BASE=2\r\n

Note: Save settings after configuring the command.

4.3.4 Configure RTK Dual antenna Mounting Angle

If the RTK Dual antenna mounting angle is configured as 0 degrees, the configuration command is:

Command : AT+RTK_ANGLE=0\r\n

Response : ANGLE=0\r\n

Description : The mounting angle is the angle between the ray from Primary antenna pointing to Secondary antenna and the vehicle heading direction. Clockwise is positive, counterclockwise is negative. Input range: -180°~180°

Note: Configuration commands take effect after saving and power cycling; the Dual antenna interval distance must be greater than 50 cm

4.3.5 Enable Dual antenna Fusion

Note: By default, Dual antenna fusion is disabled and used only for rapid initialize when stationary. To use Dual antenna heading throughout, enable Dual antenna fusion using the following command. A value of 1 enables Dual antenna fusion; other Parameter values disable Dual antenna fusion. Note that Dual antenna installation error calibration must be performed synchronously; otherwise, a fixed offset will exist between the vehicle heading.

Command :AT+DRTK_USE=1\r\n

Response : OK

Note: Configuration commands take effect after saving and power cycling; the Dual antenna interval distance must be greater than 50 cm

4.3.6 Calibrate Dual antenna

Dual antenna CalibrationProcedure is as follows

1. Connect Serial Port, input AT+SETNO\r\n to disable all printing

2. Send command AT+RTK_BIAS_EST=1\r\n to start the calibration process

3. Drive the vehicle straight at a speed of no less than 3 km/h; when Serial Port returns RTK_BIASE_CORRECT_DONE, calibration is successful

4. Send the AT+CONFIG\r\n command to view the output RTK_BIAS_FLAG_AND_VALUE=99,XX (calibration angle); check if it is reasonable. Under normal installation conditions, it should be less than 1°

5. Send AT+SAVE\r\n to save the results and power cycle the device

4.3.7 Configure the position and velocity projection points output by Integrated Navigation

To configure the projection points result set by Integrated Navigation, use the following command:

Command: AT+PROJ_VECTOR=1.0,2.0,3.0\r\n

Response : PROJ_VECTOR_X=1.0, PROJ_VECTOR_Y=2.0, PROJ_VECTOR_Z=3.0\r\n

Description : The default output of Integrated Navigation is the antenna phase center coordinates. To output coordinates for other positions, configure the lever arm vector of the IMU phase center relative to this projection points position. The configuration method is the same as lever arm configuration.

4.4 Save Parameter

After all configuration commands are set, send the save Parameter command "AT+SAVE\r\n"

5. Coordinate System Definition

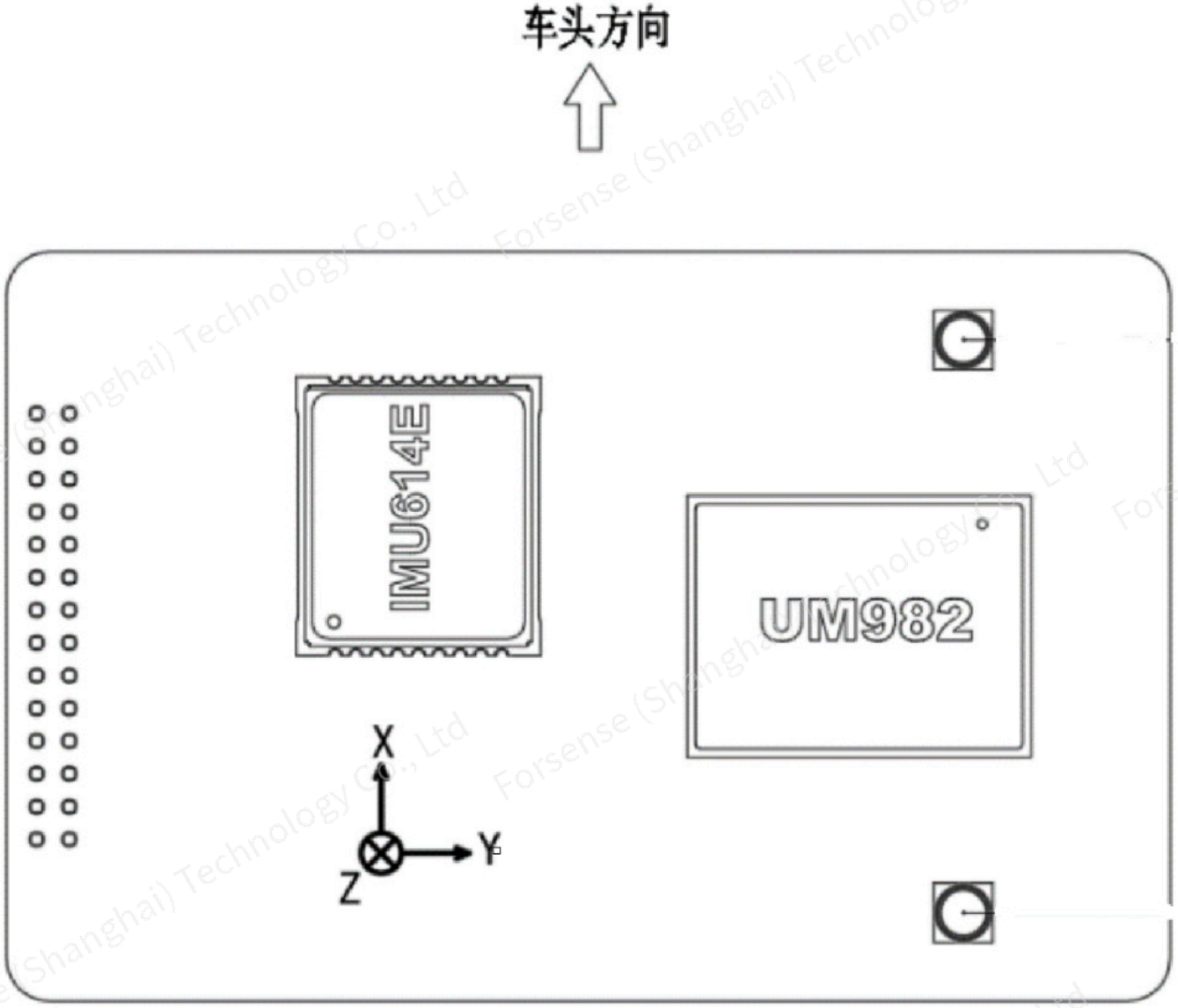


Figure11 Coordinate System Diagram

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

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

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

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

The schematic diagram of Roll, Pitch, and Yaw angle is shown below:

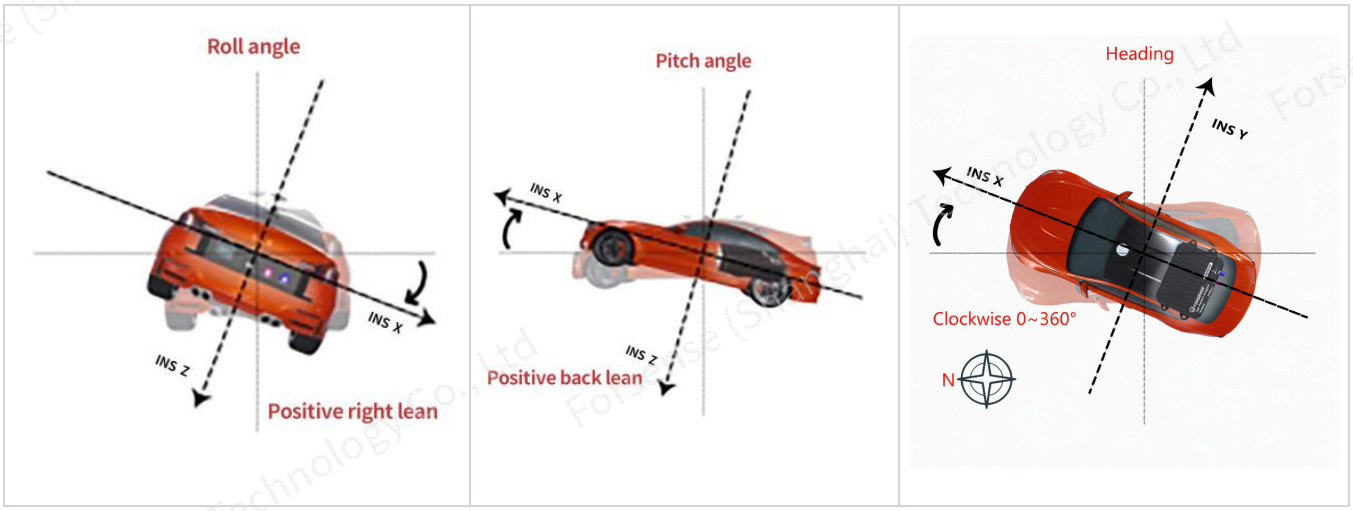


Figure12 Roll, Pitch, Yaw angle Schematic

6. Connection and Setup

6.1 Electrostatic Discharge Protection

- Many components on the FS982-AG board are susceptible to damage from electrostatic discharge, which can affect IC circuits and other elements. Please take the following ESD precautions before opening the anti-static blister pack:
- Electrostatic discharge (ESD) (ESD) can damage components. Handle the board on an anti-static workbench while wearing an anti-static wrist strap and using a conductive foam pad. If an anti-static workbench is not available, wear an anti-static wrist strap and connect it to a metal part of the chassis for ESD protection.
- Do not touch components directly when inserting or removing the board. When removing the board, carefully check for any loose or damaged components.

6.2 Power-On Startup

- The FS982-AG supply voltage is 5V. After power is applied, the receiver begins startup and quickly establishes communication.

6.3 Testing PC software Usage

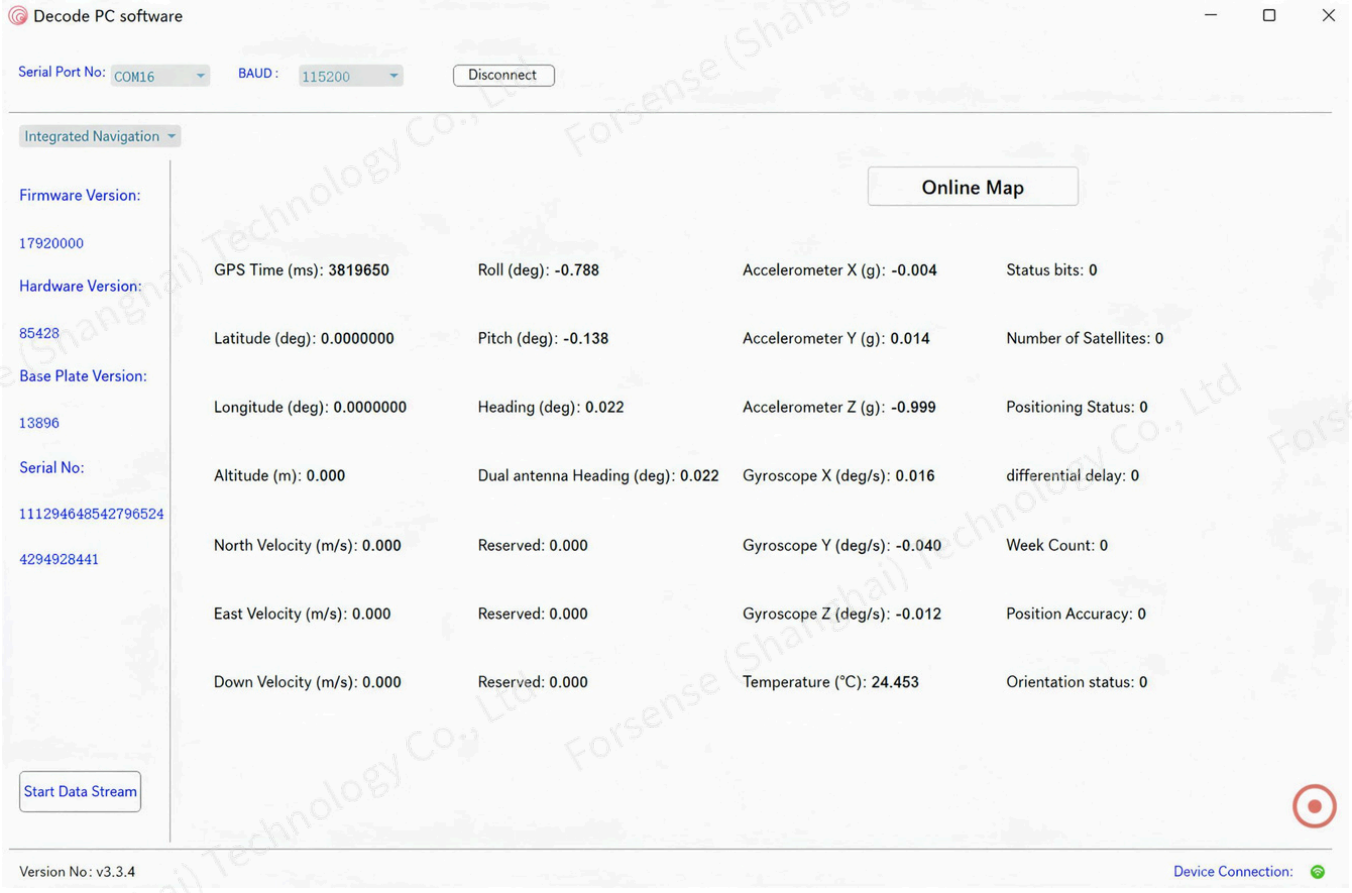
Download URL:https://data.forsense-imu.com/ProductFile/link/Upper%20computer%20software/FS982-AG%20Map%20version/download.php

Select Serial Port number and baud rate at location 1. Connect FS982 using a USB-to-RS232 Serial Port cable and provide correct power to FS982 to display the Serial Port number.

Select Integrated Navigation data stream (corresponding to Integrated Navigation binary protocol) at location 2

Location 3 displays the connected hardware name, corresponding firmware version, and product serial number;

Location 4 allows recording and saving current data



7. Board LED Indicator

FS982-AG board is equipped with an LED indicator to show the basic operating status of the board:

Table 6 Board LED Indicator

NO.	Indicator Light	Status	Description	Remarks
1	Red	Steady On	Board system self-test failed	
		Off	Board Self-Test Passed	
2	Green	Steady On	Board Can Perform Positioning	
		Steady Off	Board Cannot Perform Positioning	
3	Blue	Steady On	RTK fixed solution	
		Always Off	Other RTK Fix Statuses or No Fix	

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8. Output Protocol

8.1 Binary Protocol - AG Data Stream

Note:

- CRC check starts from Frame header, excluding the CRC check bits themselves. It covers all bytes in the frame. For calculation methods and examples, refer to the appendix.
- Frame length is the total number of data bytes excluding Frame header, Frame ID, Frame Length, and Check Bits.
- little-endian mode, send the low byte first.

Table 7 Binary Protocol - AG Data Stream

Content	Type	Relative Position
Frame header 1:0xAA	Uint8	0
Frame header 2:0x55	Uint8	1
Frame ID: 0x0156	Uint16	2
Frame Length: 0x0032	Uint16	4
seconds in GPS week(ms)	Uint32	6
Roll angle (deg)	Float	10
Pitch angle (deg)	Float	14
Yaw angle (deg)	Float	18
Reserved	Float	22
3-axis Angular velocity (deg/s, Forward-Right-Down)	Float*3	26
3-axis Acceleration (g, Forward-Right-Down)	Float*3	38
RTK Positioning Status	Uint8	50
Attitude significant bits Bit0: 1 indicates valid attitude, 0 indicates invalid Bit1: 1 indicates valid front wheel steering angle, 0 indicates invalid	Uint8	51
Status bits: bit0: 1 indicates RTK data is valid, 0 indicates invalid Bit1: 1 indicates PPS signal is valid, 0 indicates invalid Bit2: 1 indicates Integrated Navigation has been initialize, 0 indicates not initialize (single antenna initialize conditions: RTK positioning status 4 + speed above 0.5 m/s + straight-line driving with acceleration and deceleration, Dual antenna initialize Condition: RTK Fix Status 4 + RTK Orientation status 50) Bit3: 1 indicates front wheel steering angle is valid, 0 is invalid Bit4: 1 indicates Integrated Navigation has converged, 0 indicates not converged Bit5: 1 indicates front wheel gyroscope data is valid, 0 indicates invalid (ignore if no external gyroscope) Bit6: 1 indicates steering motor data is valid, 0 indicates invalid Bit7,Bit8: 01 indicates vehicle moving forward (Bit7=1, Bit8=0) 10 indicates vehicle reversing (Bit7=0, Bit8=1) 00 indicates invalid (Bit7=0, Bit8=0)	Uint32	52

CRC Check	Uint32	56

8.2 Binary Protocol - Integrated Navigation Data Stream

Note:

- CRC Check starts from Frame header and excludes the CRC check bits themselves. It covers all bytes in the frame. For calculation methods and examples, refer to the appendix.
- Frame Length is the total number of data bytes excluding Frame header, Frame ID, Frame Length, and Check Bits.
- little-endian mode, send low byte first.
- For configuration methods, refer to Section 9.1.9,Command: AT+SETNAV\r\n
- Cannot be output simultaneously with the NMEA data stream. If the binary protocol is enabled, the NMEA data stream cannot be output. Before switching data streams,send the command specified in Section 9.1.11.AT+SETNO\r\n stops the current data stream output.

Table 8 Binary Protocol - Integrated Navigation Data Stream

Content	Type	Relative Position
Frame header 1:0xAA	Uint8	0
Frame header 2:0x55	Uint8	1
Frame ID: 0x0166	Uint16	2
Frame Length: 0x005E	Uint16	4
seconds in GPS week(ms)	Uint32	6
GPS week number count	Uint16	10
Latitude (deg × 10000000)	Int32	12
Longitude (deg × 10000000)	Int32	16
Altitude (mm)	Int32	20
North Velocity (m/s)	Float	24
East Velocity (m/s)	Float	28
Down Velocity (m/s)	Float	32
Roll angle (deg)	Float	36
Pitch angle (deg)	Float	40
Yaw angle (deg)	Float	44
single antenna: AHRS Heading(deg)(No Reference Value) Dual antenna: RTKDual antenna Heading (deg) When G200 front wheel gyro is connected: Front Wheel Gyro Z-axis Angular velocity(deg/s)	Float	48
Reserved(Displays as Front Wheel Angle when G200 is connected)	Float	52
Accelerometer X-axis (g)	Float	56
Accelerometer Y-axis (g)	Float	60
Accelerometer Z-axis (g)	Float	64
Gyroscope X-axis (deg/s)	Float	68
Gyroscope Y-axis (deg/s)	Float	72

Gyroscope Z-axis (deg/s)	Float	76
IMU Temperature (°C)	Float	80
RTK Fix Status (Same as Positioning Status in GGA) 0: No Fix 1: single point positioning 2: Pseudo-range differential positioning 4:fixed solution 5:floating solution	Uint8	84
Number of Satellites	Uint8	85
differential delay	Uint8	86
Dual antenna Orientation status 50 indicates aligned Other values indicate not aligned	Uint8	87
Position Dilution of Precision (DOP) (cm) Integrated Navigation initialize Valid After	Uint16	88
Status bits: bit0: 1 indicates RTK data is valid, 0 indicates invalid Bit1: 1 indicates PPS signal is valid, 0 indicates invalid Bit2: 1 indicates Integrated Navigation has been initialize, 0 indicates not initialize (single antenna initialize conditions: RTK positioning status 4 + speed reaches above 0.5 m/s + straight-line driving with acceleration and deceleration, Dual antenna initialize condition: RTK Fix Status 4 + RTK Orientation status 50) Bit3: 1 indicates front wheel steering angle valid, 0 invalid Bit4: 1 indicates Integrated Navigation has converged, 0 indicates not converged Bit5: 1 indicates front wheel gyroscope data is valid, 0 indicates invalid (can be ignored if no external gyroscope is connected) Bit6: 1 indicates steering motor data is valid, 0 indicates invalid Bit7,Bit8: 01 indicates vehicle moving forward 10 indicates vehicle moving backward 00 indicates invalid	Uint16	90
Reserved 1	Uint32	92
Reserved 2	Uint32	96
CRC Check	Uint32	100

8.3 NMEA Protocol

- Supports output of fused data in NMEA format,
- Cannot be output simultaneously with the binary data stream. If the NMEA data stream is enabled, the binary data stream cannot be output. Before switching data streams, stop the current data stream output using the AT+SETNO\r\n command as described in Section 9.1.11.
- Currently supports the following statements.Configuration MethodSeeSection 9.1.10

GPGGA

Message Description in Chinese

Field	Structure	Description	Style	Example
1	$GPGGA	Message Header		$GPGGA
2	utc	UTC Time (Hour/Minute/Second/Fractional Second)	hhmmss.ss	202134
3	lat	Latitude (DDmm.mm)	llll.ll	5106.9847
4	lat dir	Latitude Direction (N = North, S = South)	a	N
5	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.2986
6	lon dir	Longitude Direction (E = East, W = West)	a	W
7	quality	Solution Status	x	1
8	# sats	Number of satellites used in the solution, which may differ from the number of visible satellites	xx	2
9	hdop	Horizontal Dilution of Precision (DOP)	x.x	1
10	alt	Antenna height above or below sea level	x.x	1062.22

11	a-units	Antenna height unit (M = metres)	M	M
12	undulation	Elevation Outlier	x.x	-16.271
13	u-units	Elevation Outlier Unit (M = metres)	M	M
14	age	Differential Data Age, s	xx	1
15	stn ID	Differential Base Station ID	xxxx	8
16	*xx	Checksum	*hh	*48
17	[CR][LF]	Sentence Terminator		[CR][LF]

Official Message Description

Field	Structure	Description	Symbol	Example
1	$GPGGA	Log header		$GPGGA
2	utc	UTC time status of position (hours/minutes/seconds/ decimal seconds)	hhmmss.ss	202134.00
3	lat	Latitude (DDmm.mm)	llll.ll	5106.9847
4	lat dir	Latitude direction (N = North, S = South)	a	N
5	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.2986
6	lon dir	Longitude direction (E = East, W = West)	a	W
7	quality	refer to Table: GPS Quality Indicators	x	1
8	# sats	Number of satellites in use. May be different to the number in view	xx	10
9	hdop	Horizontal dilution of precision	x.x	1.0
10	alt	Antenna altitude above/below mean sea level	x.x	1062.22
11	a-units	Units of antenna altitude (M = metres)	M	M
12	undulation	Undulation - the relationship between the geoid and the WGS84 ellipsoid	x.x	-16.271
13	u-units	Units of undulation (M = metres)	M	M
14	age	Age of correction data (in seconds) The maximum age reported here is limited to 99 seconds.	xx	(empty when no differential data is present)
15	stn ID	Differential base station ID	xxxx	(empty when no differential data is present)
16	*xx	Check sum	*hh	*48
17	[CR][LF]	Sentence terminator		[CR][LF]

GPS Quality Indicators

Indicator	Description
0	Fix not available or invalid
1	Single point
	Converging PPP (TerraStar-L)
2	Pseudorange differential
	Converged PPP (TerraStar-L)
	Converging PPP (TerraStar-C PRO, TerraStar-X)
4	RTK fixed ambiguity solution
5	RTK floating ambiguity solution
	Converged PPP (TerraStar-C PRO, TerraStar-X)
6	Dead reckoning mode
7	Manual input mode (fixed position)
8	Simulator mode
9	WAAS (SBAS)[1]

GPRMC

Message Description in Chinese

Field	Structure	Description	Style	Example
1	$GPRMC	Message Header		$GPRMC
2	utc	Fixed UTC Time	hhmmss.ss	144326
3	pos status	Positioning Status (A for Valid Fix, V for Invalid Fix)	A	A
4	lat	Latitude (DDmm.mm)	llll.ll	5107.0017737
5	lat dir	Latitude Direction (N = North, S = South)	a	N
6	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.3291611

7	lon dir	Longitude Direction (E = East, W = West)	a	W
8	speed Kn	Ground Speed	x.x	0.08
9	track true	Ground Course, referenced to True North	x.x	323.3
10	date	UTC Date: (Year/Month/Day)	xxxxxx	210307
11	mag var	Magnetic Variation	x.x	0
12	var dir	Magnetic Variation Direction	a	E
13	mode ind	Positioning Mode Indicator	a	A
14	*xx	Checksum	*hh	*20
15	[CR][LF]	Sentence Terminator		[CR][LF]

Official Message Description

Field	Structure	Description	Symbol	Example
1	$GPRMC	Log header		$GPRMC
2	utc	UTC of position	hhmmss.ss	144326.00
3	pos status	Position status (A = data valid, V = data invalid)	A	A
4	lat	Latitude (DDmm.mm)	llll.ll	5107.0017737
5	lat dir	Latitude direction: (N = North, S = South)	a	N
6	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.3291611
7	lon dir	Longitude direction: (E = East, W = West)	a	W
8	speed Kn	Speed over ground, knots	x.x	0.080
9	track true	Track made good, degrees True	x.x	323.3
10	date	Date: dd/mm/yy	xxxxxx	210307
11	mag var	Magnetic variation, degrees Note that this field is the actual magnetic variation and will always be positive. The direction of the magnetic variation is always positive.	x.x	0.0
12	var dir	Magnetic variation direction E/W Easterly variation (E) subtracts from True course. Westerly variation (W) adds to True course.	a	E
13	mode ind	Positioning system mode indicator, see Table: NMEA Positioning System Mode Indicator	a	A
14	*xx	Check sum	*hh	*20
15	[CR][LF]	Sentence terminator		[CR][LF]

NMEA Positioning System Mode Indicator

Mode	Indicator
A	Autonomous
D	Differential
E	Estimated (dead reckoning) mode
M	Manual input
N	Data not valid

GPHDT (Heading Information)

Message Description in Chinese

Field	Structure	Description	Style	Example
1	$GPHDT	Message Header		$GPHDT
2	heading	Yaw angle	x.x	75.5554
3	TRUE	True North Angle	T	T
4	*xx	Checksum	*hh	*36

5	[CR][LF]	Statement Terminator		[CR][LF]

Official Message Description

Field	Structure	Description	Symbol	Example
1	$GPHDT	Log header		$GPHDT
2	heading	Heading in degrees	x.x	75.5554
3	True	Degrees True	T	T
4	*xx	Check sum	*hh	*36
5	[CR][LF]	Sentence terminator		[CR][LF]

GPVTG (Ground Speed Information)

Message Description in Chinese

Field	Structure	Description	Style	Example
1	$GPVTG	Message Header		$GPVTG
2	track true	Heading Angle, Referenced to True North	x.x	24.168
3	T	True North Indicator	T	T
4	track mag	Heading Angle, Referenced to Magnetic North	x.x	24.168
5	M	Magnetic North Indicator	M	M
6	speed Kn	Horizontal Velocity	x.x	0.4220347
7	N	Speed Indicator, Knots	N	N
8	speed Km	Horizontal Velocity, km/s	x.x	0.781608
9	K	Speed Indicator (K = km/hr)	K	K
10	mode ind	Positioning Mode Indicator	a	A
11	*xx	Checksum	*hh	*7A
12	[CR][LF]	Statement Terminator		[CR][LF]

Official Message Description

Field	Structure	Description	Symbol	Example
1	$GPVTG	Log header		$GPVTG
2	track true	Track made good, degrees True	x.x	24.168
3	T	True track indicator	T	T
4	track mag	Track made good, degrees Magnetic; Track mag = Track true + (MAGVAR correction) See the **MAGVAR** command	x.x	24.168
5	M	Magnetic track indicator	M	M
6	speed Kn	Speed over ground, knots	x.x	0.4220347
7	N	Nautical speed indicator (N = Knots)	N	N
8	speed Km	Speed, kilometres/hour	x.x	0.781608
9	K	Speed indicator (K = km/hr)	K	K
10	mode ind	Positioning system mode indicator, see Table: NMEA Positioning System Mode Indicator	a	A
11	*xx	Check sum	*hh	*7A
12	[CR][LF]	Sentence terminator		[CR][LF]

NMEA Positioning System Mode Indicator

Mode	Indicator
A	Autonomous
D	Differential
E	Estimated (dead reckoning) mode
M	Manual input
N	Data not valid

GPZDA (UTC Time and Date)

Message Description in Chinese

Field	Structure	Description	Style	Example
1	$GPZDA	Message Header		$GPZDA
2	utc	UTC Time	hhmmss.ss	220238
3	day	Day, 01 -31	xx	15
4	month	Month, 01-12	xx	7
5	year	Year	xxxx	1992
6	null	Local Area Code, Not Available	xx	(empty when no data is present)
7	null	Local Zone Minute Description, Not Available	xx	(empty when no data is present)
8	*xx	Checksum	*hh	*6F
9	[CR][LF]	Statement Terminator		[CR][LF]

Official Message Description

Field	Structure	Description	Symbol	Example
1	$GPZDA	Log header		$GPZDA
2	utc	UTC time status	hhmmss.ss	220238.00
3	day	Day, 01 to 31	xx	15
4	month	Month, 01 to 12	xx	07
5	year	Year	xxxx	1992
6	null	Local zone description—not available Local time zones are not supported by OEM7 family receivers. Fields 6 and 7 are always null.	xx	(empty when no data is present)
7	null	Local zone minutes description—not available	xx	(empty when no data is present)
8	*xx	Check sum	*hh	*6F
9	[CR][LF]	Sentence terminator		[CR][LF]

GPATT (Forsense Custom Message)

Name	Unit	Style	Example	Description
Message Header		String	$GNATT	
UTC Time		hhmmss.sss	170834.000	17:08:34 UTC
Status		Character	1	0: Unavailable 1: Available
Roll angle	degree	3 decimal place	-4.891	Range is ±180°, defined as positive when pointing right and down is positive
Roll angle Indicator		Character	R	Roll angle Indicator
Pitch angle	degree	3 decimal place	3.122	Range is ±90°, defined as positive when pointing up is positive
Pitch angle Indicator		Character	P	Pitch angle Indicator
Yaw angle	degree	3 decimal place	124.005	Range: 0° to 360°, True North, clockwise positive
Roll angle Uncertainty	degree	3 decimal place	0.432	Range: 0~360
Pitch angle Uncertainty	degree	3 decimal place	0.811	Range: 0~360
Yaw angle Uncertainty	degree	3 decimal place	1.202	Range: 0~360
Checksum		HEX	*68	Used to check for transmission errors

The GPATT format is shown in the table below

Name	*Unit*	*Format*	*Example*	*Description*
Sentence Identifier		String	$GNATT	
Time		hhmmss.sss	170834.000	17:08:34 UTC
Status		Character	1	0: invalid 1: valid
Roll Angle	degree	3 decimal places	-4.891	range ±90, right side down defined as positive
Indicator for roll		character	R	Roll indicator
Pitch Angle	degree	3 decimal places	3.122	range ±90, head up defined as positive
Indicator for Pitch		character	P	Pitch indicator
Heading Angle	degree	3 decimal places	124.005	range 0~360, to true North, counter clockwise defined as positive
Roll Angle uncertainty	degree	3 decimal places	0.432	range 0~360
Pitch Angle uncertainty	degree	3 decimal places	0.811	range 0~360
Heading Angle uncertainty	degree	3 decimal places	1.202	range 0~360
Checksum		Hex	*68	Used by program to check for transmission errors

GPCHC (Forsense Custom Message: GPCHC Data Protocol)

The GPCHC format is shown in the table below

$GPCHC,GPSWeek,GPSTime,Heading,Pitch,Roll,gyrox,gyroy,gyroz,accx,accy,accz,Lattitude,Longitude,Altitude,Ve,Vn,Vu,V,NSV1,NSV2,Status,Age,WarmingCs<CR><LF>

Note: If the system status does not initialize, it represents GNSS results, including position, velocity, and attitude (Status lower nibble 0, 1 for GNSS data; 2, 3 for fused data)

Field	Name	Description	Format	Example
1	Header	GPCHC Message Header	$GPCHC	$GPCHC
2	GPSWeek	Number of weeks from 1980-1-6 to the present (GPS time)	www	1980
3	GPSTime	Seconds Since Sunday 0:00:00 of Current Week (GPS Time)	ssssss.ss	16897.68
4	Heading	Yaw Angle (0 to 359.99)	hhh.hh	289.19
5	Pitch	Pitch angle (-90 to 90)	+/-pp.pp	-0.42
6	Roll	Roll angle (-180 to 180)	+/-rrr.rr	0.21
7	gyro x	Gyro X Axis, Unit (°/s)	+/-ggg.gg	-0.23
8	gyro y	Gyro Y Axis, Unit (°/s)	+/-ggg.gg	0.07
9	gyro z	Gyro Z Axis, Unit (°/s)	+/-ggg.gg	-0.06
10	acc x	Accelerometer X Axis, Unit (G)	+/-a.aaaa	0.0009
11	acc y	Accelerometer Y Axis, Unit (G)	+/-a.aaaa	0.0048
12	acc z	Accelerometer Z Axis, Unit (G)	+/-a.aaaa	-1.0037
13	Latitude	Latitude (-90° to 90°)	+/-ll.lllllll	38.8594969
14	Longitude	Longitude (-180° to 180°)	+/-ll.lllllll	121.5150073
15	Altitude	Altitude (Unit: m)	+/-aaaaa.aa	121.51
16	Ve	East Velocity (Unit: m/s)	+/-eee.eee	-0.023
17	Vn	North Velocity (Unit: m/s)	+/-nnn.nnn	0.011
18	Vu	Up Velocity (Unit: m/s)	+/-uuu.uuu	0.000
19	V	Vehicle Speed (Unit: m/s)	+/-uuu.uuu	1.500
20	NSV1	Primary antenna 1 Satellite Count	nn	14
21	NSV2	Secondary antenna 2 Number of Satellites	nn	6
22	Status	System Status (Lower Nibble): 0: initialize ; 1: Satellite Navigation Mode ; 2: Integrated Navigation Mode ; 3: Pure Inertial Navigation Mode ; Satellite Status (Upper Nibble): 0: No Positioning and No Attitude; 1: single point positioning Attitude; 2: Pseudo-range differential positioning Attitude; 3: Combined Dead Reckoning; 4: RTK Fixed Solution Positioning and Attitude; 5: RTK floating solution Positioning and Attitude; 6: single point positioning No Attitude; 7: Pseudo-range differential positioning No Attitude; 8: RTK Fixed Solution Positioning No Attitude; 9: RTK floating solution Positioning No Attitude;	ss	4
23	Age	differential delay	aa	0
24	Warning	bit0:1: No GPS message, 0: Normal bit1:1: No vehicle message, 0: Normal bit3:1: Gyro error, 0: Normal bit4:1: Accelerometer error, 0: Normal	ww	2
25	Cs	Checksum	*hh	*47
26	<CR><LF>	Fixed Packet Tail		<CR><LF>

8.4 CAN Protocol

Table9 CAN Extended Frame Format 0x19FF CC9A (Note: Unit is deg*100, int16 type)

Extended Frame ID	1	2	3	4	5	6	7	8
0x19FF CC9A	Roll angle		Pitch angle		Yaw angle		track angle	

Table10CAN Extended Frame Format 0x19FF CD9A (Note: Unit is deg/s*52.0127, int16 type)

Note: Reserved: If connected to G200, outputs the front wheel angle

Extended Frame ID	1	2	3	4	5	6	7	8
0x19FF CD9A	gyro_x		gyro_y		gyro_z		Reserved	

Table11 CAN Extended Frame Format 0x19FF CE9A (Note: Unit is g*3276.8, int16 type)

Status bits:

Bit0: RTK Board Data valid flag bit, 1 indicates valid, 0 indicates invalid

Bit1: PPS valid flag bit, 1 indicates valid, 0 indicates invalid

Bit2: Front Wheel Steering Angle valid flag bit, 1 indicates valid, 0 indicates invalid

Bit3: Front Wheel Gyroscope valid flag bit, 1 indicates valid, 0 indicates invalid

Bit4: RTK Positioning fixed solution Flag, 1 indicates fixed solution, 0 indicates not fixed solution

Bit5: RTK Heading fixed solution Flag, 1 indicates fixed solution, 0 indicates not fixed solution

Bit6: Yaw initialize Flag, 1 indicates initialize, 0 indicates not initialize (only for single antenna vehicle gyro)

Extended Frame ID	1	2	3	4	5	6	7	8
0x19FF CE9A	accel_x		accel_y		accel_z		Status bits	

Table12CAN Extended Frame Format 0X19FFCE9B(Note: Speed Direction: 1: Forward, -1: Reverse)

Extended Frame ID	1	2	3	4	5	6	7	8
0X19FFCE9B	Seconds of Week				Estimated Antenna Installation Bias Angle		Track Angle	Reserved

Table13 CAN Extended Frame Format 0X19CCFF9A (Note: The format is in degrees and needs to be divided by 1e7, Int32 type)

The device uses the WGS84 coordinate system. Latitude and longitude are output at the Primary antenna phase center by default; when projection points is configured, they are output at the projection points position;

Latitude is measured from the equator as 0°; a Latitude greater than 0° indicates the Northern Hemisphere, otherwise the Southern Hemisphere;

Longitude is measured from the Prime Meridian as 0°; a Longitude greater than 0° indicates the Eastern Hemisphere, otherwise the Western Hemisphere.

Extended Frame ID	1	2	3	4	5	6	7	8
0X19CCFF9A	Latitude				Longitude			

Table14 CAN Extended Frame Format 0X19CCFF9B (Note: Elevation is Ellipsoidal height, needs to be divided by 1e7, Int32 type)

Extended Frame ID	1	2	3	4	5	6	7	8
19CCFF9B	Elevation				Seconds of Week			

Table15CAN Extended Frame Format 0X19FFD29A(Note: Unit is cm/s, int16 type)

Extended Frame ID	1	2	3	4	5	6	7	8
19FFD29A	North Velocity		East Velocity		Down Velocity		Ground Speed (Horizontal)	

8.5 RTK Positioning Status Table

Table 16 RTK Positioning Status Table

Binary	ASCII	Description
0	NONE	No Solution
1	FIXEDPOS	Position specified by FIX POSITION command
2	FIXEDHEIGHT	Not Supported
8	DOPPLER_VELOCITY	Velocity derived from instantaneous Doppler information
16	SINGLE	single point positioning
17	PSRDIFF	Pseudo-range differential positioning
18	WAAS	SBAS Positioning
32	L1_FLOAT	L1 floating solution
33	IONOFREE_FLOAT	Floating solution for mitigating ionospheric effects
34	NARROW_FLOAT	Narrow lane floating solution
48	L1_INT	L1 fixed solution
49	WIDE_INT	Wide lane fixed solution
50	NARROW_INT	Narrow-lane fixation Solution

9. Parameter Configuration

9.1 Via Serial Port Configuration

9.1.1 ConfigurationPrimary antennaLever Arm

For example, setlever arm vector to X=0.5m,Y=-0.6m,Z=-1.0m

Command: AT+CLUB_VECTOR=0.5,-0.6,-1.0\r\n

Response: GPS_POS_X=0.5,GPS_POS_Y=-0.6,GPS_POS_Z=-1.0\r\n

Description: lever arm vector is the 3D vector (X,Y,Z) of the RTK Primary antenna phase center relative to the IMU phase center, in meters. Where,

In the front-right-down vehicle body coordinate system

If the RTK Primary antenna is forward of the IMU, it is positive; otherwise, it is negative;

If the RTK Primary antenna is to the right of the IMU, it is positive; otherwise, it is negative;

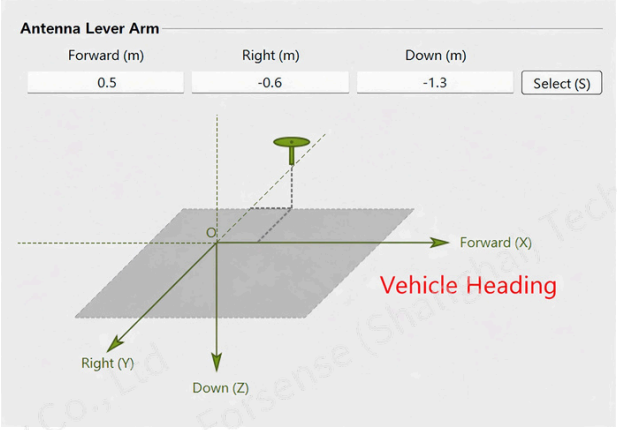
If the RTK Primary antenna is above the IMU, it is**negative**, otherwise positive (typically the antenna is above the device).

The coordinate system is illustrated in the figure below: (the label must face upward; if the IMU is not installed as shown, configure the installation orientation)

Figure13 Coordinate System Diagram



Figure14 Antenna Lever Arm Diagram



9.1.2 Configure Rear Axle Center Lever Arm

For exampleLever Arm of Rear Axle Centeris X=0.5m,Y=-0.6m,Z=1.0m

Command: AT+OD_VECTOR=0.5,-0.6,1.0\r\n

Response: OD_POS_X=0.5,OD_POS_Y=-0.6,OD_POS_Z=1.0\r\n

Note:Rear Axle Center Lever ArmThe three-dimensional vector (X,Y,Z) from the IMU phase center to the rear axle center, in meters. Where,

In the front-right-down vehicle body coordinate system

If the rear axle center is forward of the IMU, it is positive; otherwise, it is negative;

If the rear axle center is to the right of the IMU, it is positive; otherwise, it is negative;

If the rear axle center is below the IMU, it is**positive**, otherwise negative (typically the rear axle center is below the device).

The coordinate system diagram is shown below: (the label must face upward; if the IMU is not installed as shown in the figure, the installation orientation must be configured)



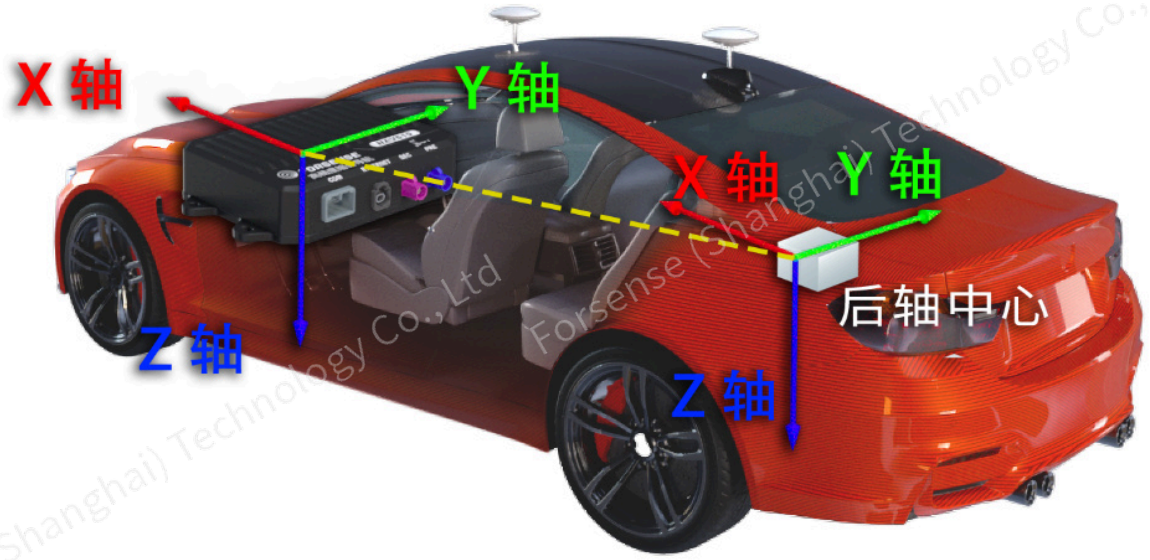


Figure 15 Coordinate System Diagram

9.1.3 Configure Vehicle Wheelbase

If the vehicle wheelbase is configured as 2m, the configuration command is:

AT+WHEEL_BASE=2\r\n

Note: Save settings after executing the command.

9.1.4 Configure RTK Dual antenna Mounting Angle

If the RTK Dual antenna mounting angle is configured as 0 degrees, the configuration command is:

Command : AT+RTK_ANGLE=0\r\n

Response : ANGLE=0\r\n

Description : The mounting angle is the angle between the ray from Primary antenna pointing to Secondary antenna and the vehicle heading direction. Clockwise is positive, counter-clockwise is negative. Input range: -180°~180°

Note: Configuration commands take effect after saving and power cycling; the Dual antenna separation distance must be greater than 50 cm

9.1.5 Enable Dual antenna Fusion

Remark: By default, Dual antenna fusion is disabled and used only for rapid initialize when stationary. To use Dual antenna heading throughout, enable Dual antenna fusion via the following command. A value of 1 enables Dual antenna fusion; other Parameter values disable Dual antenna fusion. Note that synchronous calibration of Dual antenna installation error is required to avoid a fixed offset relative to vehicle heading.

Command : AT+DRTK_USE=1

Response : OK

Note: Configuration commands take effect after saving and power cycling; the Dual antenna separation distance must be greater than 50 cm

9.1.6 CalibrationDual antenna

Dual antenna Calibration Procedure

1. Connect Serial Port, enter AT+SETNO\r\n to disable all prints

2. Send command AT+RTK_BIAS_EST=1\r\n to start the calibration process

3. Drive the vehicle straight at a speed of no less than 3 km/h; when Serial Port returns RTK_BIASE_CORRECT_DONE, calibration is successful

4. Send the AT+CONFIG\r\n command to view the output RTK_BIAS_FLAG_AND_VALUE=99,XX (calibration angle); verify its reasonableness. With proper installation, it should be less than 1°

5. Enter AT+SAVE\r\n to save the results and power cycle the device.

9.1.7 Configure Position and Velocity Output for Integrated Navigation via projection points

To configure the output using the projection points settings defined by Integrated Navigation, use the following command:

Command : AT+PROJ_VECTOR=1.0,2.0,3.0

Response : PROJ_VECTOR_X=1.0, PROJ_VECTOR_Y=2.0, PROJ_VECTOR_Z=3.0/r/n

Note: The default output of Integrated Navigation is the antenna phase centercoordinates, if other positioncoordinates are required, configure theprojection points of the IMU phase center relative to this projection pointsThe lever arm vector of the position; the configuration method is the same as for lever arm configuration.

9.1.8 Configure Binary Output - AG Data Stream

IfConfiguring AG Data Stream Output disables the 8.2 Integrated Navigation Data Stream and 8.3 NMEA Protocol Outputs

To switch to the 8.2 Integrated Navigation data stream or 8.3 NMEA protocol output, first stop the current data stream output using the command in Section 9.1.11.

Command: AT+SETAG\r\n

Response: OK\r\n

If configured to stop output

Command: AT+SETNO\r\n

Response: OK\r\n

9.1.9 Configure OutputBinary Integrated Navigation Data Stream

If Integrated Navigation data stream output is configured, then 8.1 AG Data Stream and 8.3 NMEA Protocol will not output.

To switch to 8.2 Integrated Navigation Data Stream or 8.3 NMEA Protocol Output, first stop the current data stream output using the command in 9.1.11

The configuration commands are as follows

Command: AT+SETNAV\r\n

Response: OK\r\n

If configured to stop output

Command: AT+SETNO\r\n

Response: OK\r\n

9.1.10 Configure NMEA format data stream output

If NMEA sentence output is configured,8.2Integrated Navigation data stream will not be output

To switch to8.2Integrated Navigation data stream output, first use the command AT+SETNO\r\n in Section 9.1.11 to stop the current data stream output

The configuration commands are as follows

GPGGA

Example: Output GPGGA sentences at a frequency of 5 Hz: AT+GPGGA=5\r\n

Response: OK\r\n

GPRMC

Example: Output GPRMC sentences at a frequency of 1 Hz: AT+GPRMC=1\r\n

Response: OK\r\n

GPHDT (Heading Information)

Example: Output GPHDT sentences at a frequency of 1 Hz: AT+GPHDT=1\r\n

Response: OK\r\n

GPVTG (Ground Speed Information)

Example: Output GPVTG sentences at a frequency of 1 Hz: AT+GPVTG=1\r\n

Response: OK\r\n

GPZDA (UTC Time and Date)

Example: Output GPZDA sentences at a frequency of 1 Hz: AT+GPZDA=1\r\n

Response: OK\r\n

GPATT (Custom Message)

Example: Output GPATT sentences at a frequency of 1 Hz: AT+GPATT=1\r\n

Response: OK

If configured to stop output

Command: AT+SETNO

Response: OK

9.1.11 Configure current data stream to stop output

Command: AT+SETNO

Response: OK

9.1.12 Configure Data Output Frequency

If the data output frequency is configured to 10H Hz, the configuration command is:

Note: Maximum support is 100Hz

Command : AT+OUTRATE=10

Response : OK

9.1.13 Configure Baud Rate

Only baud rates of 115200 or 230400 are supported; the default baud rate is 115200

If configuring IMU serial port baud rate to 230400, the command is:

Command : AT+BAUD=230400

Response : BAUD=230400

Note: The configuration command takes effect after saving and power cycling.

9.1.14 Configure CAN Baud Rate

Only baud rates of 250K, 500K, and 1M are supported. The default baud rate is 500K.

Example: To configure the CAN baud rate to 500K, use the following command:

Command: AT+CAN_BAUD=500\r\n

Response: OK

Note: The configuration command takes effect after saving and power cycling.

9.1.15 Configure CAN Output Frequency

To configure the CAN data output frequency to 10 Hz, use the following command:

Command: AT+CAN_ODR=10

Response: OK\r\n

Note: Maximum supported frequency is 100 Hz. Changes take effect immediately; settings persist after power cycle if saved.

9.1.16 Print All Configuration Information

To query all configured information, use the following command:

AT+CONFIG\r\n

9.1.17 Query Firmware Version

AT+VERSION\r\n

9.1.18 Configure Output Body XYZ Velocity

After configuration and initialize completion, the North, East, and Down velocities in the combined data stream switch to the carrier's XYZ axis velocities.

1 enables carrier velocity output; other Parameter values disable it.

Command: AT+NAV_OUTPUT_XYZ=1\r\n

Response: OK

9.1.19 Subtract gravitational acceleration from acceleration data

1. Command to remove gravitational acceleration: AT+DEDUCTIONG=1\r\n

A returned OK indicates successful transmission and immediate effect.

Send AT+SAVE\r\n to save the configuration; otherwise, it will be lost after reboot.

2. Command to restore gravity acceleration: AT+DEDUCTIONG=0\r\n

A response of OK indicates successful transmission and immediate effect.

Send AT+SAVE\r\n to save the configuration; otherwise, it will be lost after a restart.

9.1.20 Configure Installation Rotation Angle

Currently, only the following rotation angles are supported:

X-axis rotation by 180 degrees

Z-axis rotation by 90, 180, or 270 degrees

The configuration commands are as follows:

If the installation rotation angle is 180 degrees around the X-axis, the configuration command is:

Command: AT+INSTALL_ANGLE=180,0,0

Response: INST_ANGLE_X=180.000,INST_ANGLE_Y=0.000,INST_ANGLE_Z=0.000

If the installation rotation angle is 180 degrees around the Z-axis, the configuration command is:

Command: AT+INSTALL_ANGLE=0,0,180

Response: INST_ANGLE_X=0.000,INST_ANGLE_Y=0.000,INST_ANGLE_Z=180.000

9.1.21 Save Parameter

The above parameters, including lever arm, data stream, and output frequency, require a save command after configuration to take effect upon restart.

Command: AT+SAVE

Response: OK

9.2 Configure via CAN

Note: All CAN messages are little-endian mode, with the low byte first

9.2.1 Query Firmware Version

Example:

ID = 0x19FFF326

Data = 0x9A 0x07 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

Example: (Version 1805)

ID = 0x19FFF29A

Data = 0x26 0xC7 0x00 0x00 0x07 0x0D 0xFF 0xFF

Note: The first two bytes 0x26 0xC7 are fixed Frame header

9.2.2 Configure Wheelbase and Lever Arm

Example

ID = 0X0DFFC126

Data = Wheelbase 2 Bytes + Lever Arm 2 Bytes * 3 (Unit: cm)

Response

ID = 0X19FFC09A

Data = Wheelbase 2 Bytes + Lever Arm 2 Bytes * 3 (Unit: cm)

9.2.3 Query Wheelbase and Lever Arm

ID = 0X0DFFC226

Data =0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID = 0X19FFC29A

Data = Wheelbase (2 bytes) + Lever Arm (2 bytes * 3) (Unit: cm)

9.2.4 Configure CAN Output Update Rate and Baud Rate

Supported baud rates are 1M, 500K, and 250K (represented as 0x01, 0x02, and 0x03 respectively).

Update Rate supports 20, 50, and 100Hz (represented as 0x14, 0x32, and 0x64 respectively).

Restart to apply the configuration.

ID = 0x19FFF326

Data = 0x9A 0x4A Baud Rate Update Rate 0xFE 0xFB 0xF9 0xFF

Response

ID =0x19FFF59A

Data = 0xFF 0x4A Baud Rate Update Rate 0xFF 0xFF 0xFF 0xFF

9.2.5 Query Update Rate and Baud Rate:

ID = 0x19FFF426

Data =0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID =0x19FFF49A

Data =0xFF 0x4A Baud Rate Update Rate 0XFF 0XFF 0XFF 0xFF

9.2.6 Configure Rear Wheel Center Lever Arm

ID = 0X0BC00114

Data=Lever Arm 2 Bytes*3+FF*2 (Unit cm)

Response

ID=0X0BCBB114

Data=Lever Arm 2 Bytes*3+FF*2 (Unit cm)

9.2.7 Configure projection points Lever Arm

ID = 0X0BC00111

Data = Lever Arm (2 bytes * 3) + 00 * 2 (Unit: cm)

9.2.8 Query projection points Lever Arm

ID = 0X0BCFF111

Data=0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID = 0X0BCBB111

Data = Lever Arm (2 bytes * 3) + 00 * 2 (Unit: cm)

9.2.9 Configure Dual antenna Mounting Misalignment Angle

ID = 0X0DFFC326

Data = Angle (init16) + FF * 6 (Unit: deg * 100)

9.2.10 Query Dual antenna Mounting Misalignment Angle

ID = 0X0DFFC526

Data=0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID = 0X19FFC29A

Data=Angle+FF*6 (Unit: deg*100)

9.2.11 Configure Low-Pass Filter

ID = 0X0DFFC626

Data=Filter Value 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID=0X19FF69A

Data=Filter Value 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

9.2.12 Query Low-Pass Filter

ID=0X0DFFC726

Data=0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID=0X19FF79A

Data=Filter Value 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

9.2.13 Enable PPS(Standard Frame)

ID=0x400

Data=0X00 0X00 0X00 0X00 0X00 0X00 0X00 0X00

Response

ID=0XBCBB116

Data=0X00 0X00 0X00 0X00 0X00 0X00 0X00 0X00

9.2.14 Disable PPS(Standard Frame)

ID=0x399

Data=0X00 0X00 0X00 0X00 0X00 0X00 0X00 0X00

Response

ID=0xBCBB116

Data=0X01 0X00 0X00 0X00 0X00 0X00 0X00 0X00

9.2.15 Configure IMU Installation Rotation Angle

The first 6 bytes represent the rotation angle of each axis in pairs of two bytes

Example: X-axis rotated 180 degrees

ID:0X0BC00110

Data =B4 00 00 00 00 00 00 00

9.2.16 Query Configured IMU Installation Rotation Angle

ID:0X0BCFF110

Data =00 00 00 00 00 00 00 00

Response:

ID:0X0BCBB110

Data =B4 00 00 00 00 00 00 00

9.2.17 Configure Dual antenna Fusion Enable/Disable

Setting to 0x99 indicates enabled; other values indicate disabled

Example: Configure Dual antenna Fusion Enable

ID:0X0BC00115

Data =99 00 00 00 00 00 00 00

Response

ID:0X0BCBB115

Data =01 00 00 00 00 00 00 00

9.2.18 Save Parameter Command

ID = 0X0DFFCF26

Data =0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

Response

ID = 0X19FFCF9A

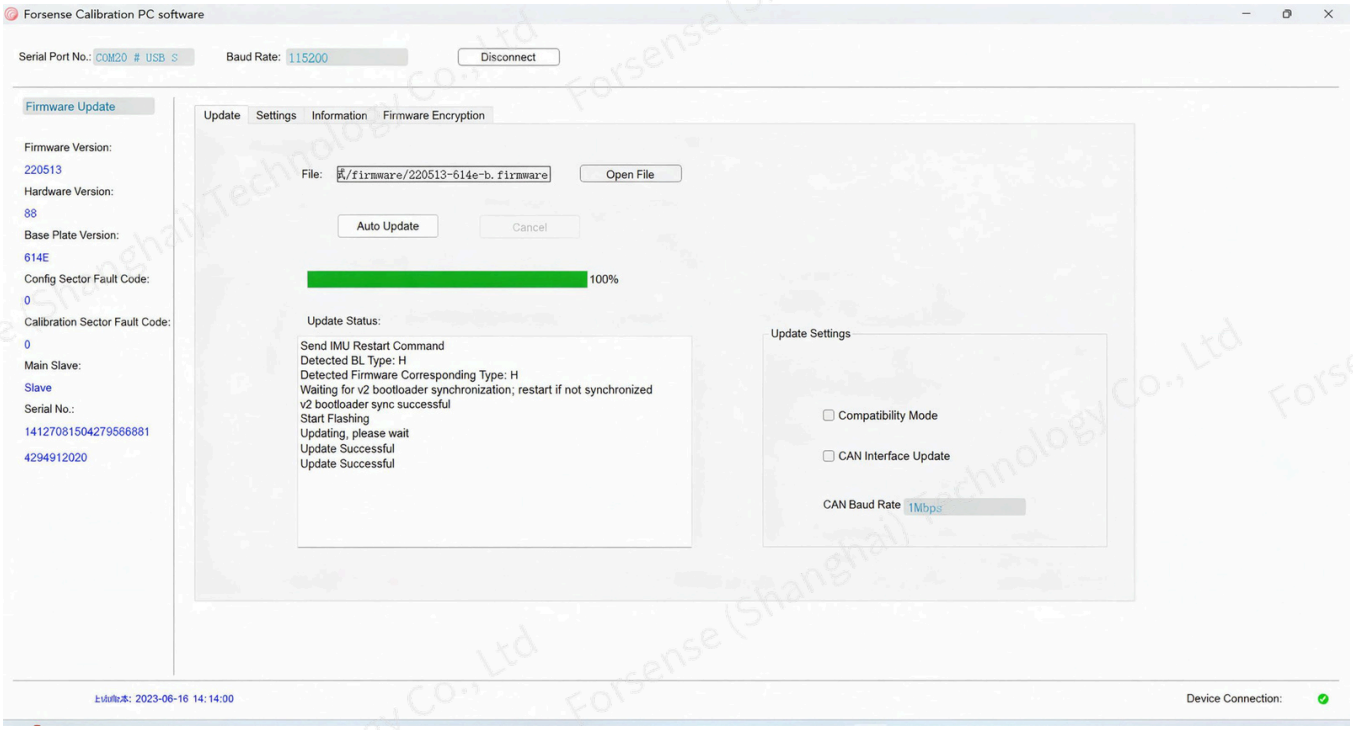
Data=0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF

10. Firmware Update

10.1 Via PC software

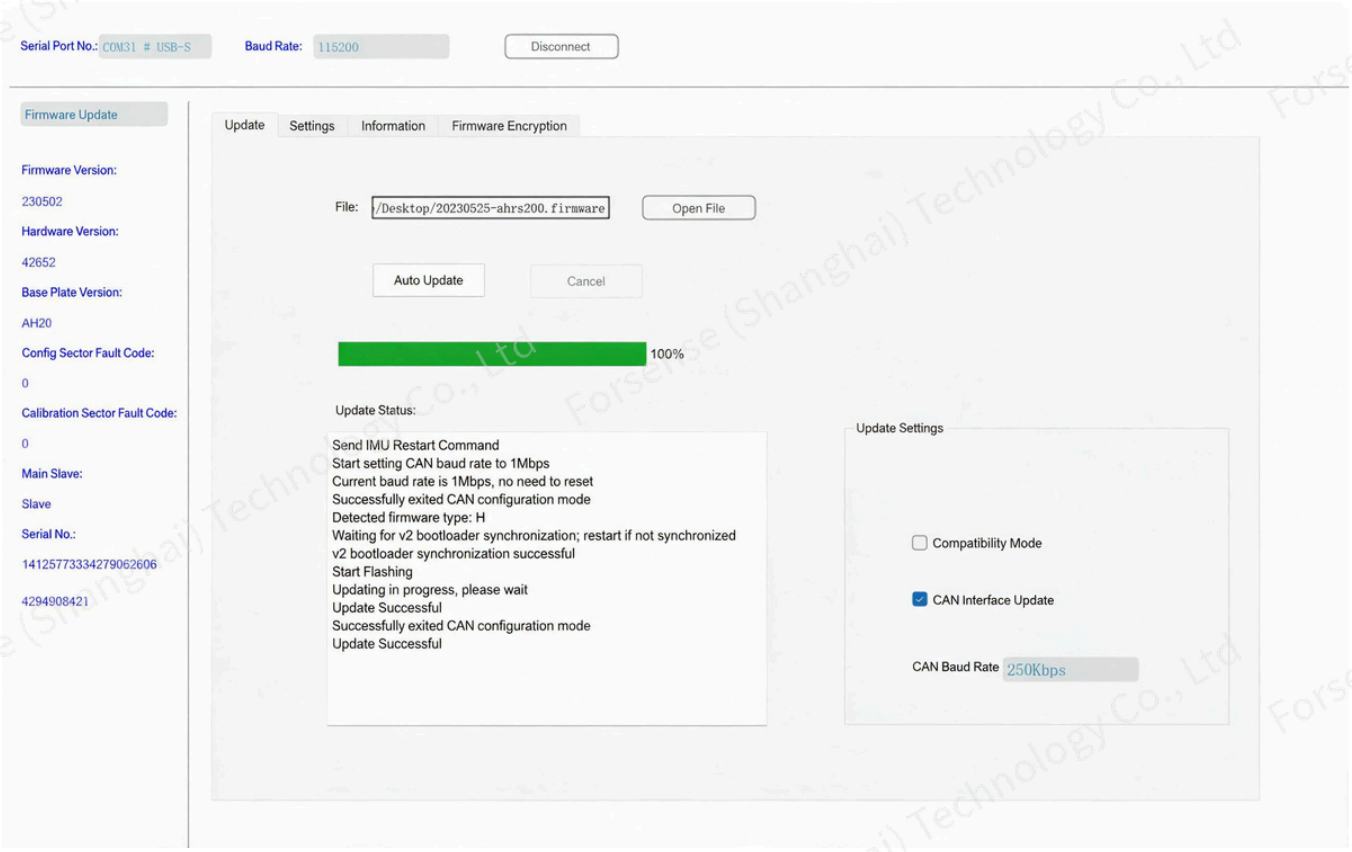
10.1.1 RS232

Use Forsense IMU to Test PC software — Select Firmware Update — Open Firmware — Click Auto Upgrade.



10.1.2 CAN - Via Attached USB-to-CAN Module

Use Forsense IMU to test PC software — Select Firmware Update — Open Firmware — Select CAN Interface Upgrade — Set the baud rate for the upgraded firmware — Click Auto Upgrade.



10.2 serial push

The upgrade consists of the following steps:

Step 1: Send Upgrade Command

Send the upgrade command to notify the module to prepare for the upgrade. After the command is sent, the device records an upgrade flag in a specific flash area and then performs a soft reset. At this point,IMUthe module enters the BOOTLOADER.

```
上位机发送升级指令如下：
  cmd_bl[34] ={0x55,0xaa,0xbb,0x88,0x18,0x00,0x00,0x00,0xc8,0x42,0x00,0x00,
  0x48,0x43,0x2c,0x01,0x00,0x00,0x90,0x01,0x00,0x00,0xf4,0x01,0x00,0x00,
  0x58,0x02,0x00,0x00,0x40,0x97,0x46,0x6a};
  此时 imu 模块将会重启后进入 bootloader 中
```

Step 2: Send **HC32MCU_FORSENSE** String

IMU After the module enters bootloader mode,IMU the module actively sends the HC32_UPLOADER string. During this period, PC software needs to send the HC32MCU_FORSENSE string.IMU Once the module receives this string, it will not jump to the APP but remain in bootloader mode in a state ready for firmware update, and also

will stop actively sending any messages

```
//发送完升级指令后，紧接着发送如下字符串，确保 imu 模块不会跳转到 APP 区域，同时处于待升级状态
```

```
QString str = "HC32MCU_FORSENSE" ;
for(int i=0;i<10;i++)
{
  _port_device->write(str.toLatin1()); sleep_ms(50);
}
```

Step 3: Send Synchronization Command

IMU When the module is in the bootloader and waiting for an upgrade, it does not actively send information but only passively responds to commands from PC software. At this point, after PC software sends the command Send_CMD_LONG(0X21,0,0,0,0,0,0), wait IMU for the module's response . IMU Upon receiving this command, immediately reply with Send CMD ACK (0x64,0x10,0) data . Once PC software detects that this data has been received, synchronization is considered complete.

```
上位机与 imu 模块同步过程：
1.上位机发送同步命令，命令码为 0x21，发送后等待 imu 模块响应
 Send_CMD_LONG(0x21,0,0,0,0,0,0);
2.imu 模块收到 0x21 的命令码后，发送响应数据，数据命令如下：
Send_CMD_ACK(0x64,0x10,0);
3.上位机判断是否收到了 imu 的响应数据，如收到则表示完成了同步
注：Send_CMD_LONG 函数与 Send_CMD_ACK 函数见文章末尾
```

Step 4: Send Erase Command

PC software sends the erase command Send_CMD_LONG(0x23,0,0,0,0,0,0). After the command is sent,IMU the module erases all content in the APP area and reports the final execution result to PC software. PC software determines whether to resend the erase command based on the execution result. Once the erase operation succeeds,IMU the module's APP cannot be restored. Additionally, PC software must wait untilIMU a successful erase response is received before proceeding to the next step; otherwise, subsequent upgrade failures may occur.

```
1.上位机发送擦除命令，命令码为 0x23，发送完此命令后耐心等待 imu 回复执行结果
  Send_CMD_LONG(0x23,0,0,0,0,0,0);
2.imu 收到 0x23 的命令码后，将会把 APP 区域数据擦除干净，并将最终的执行结果回复给上位机
  send_CMD_ACK(0x64,0x10,0); //表示擦除成功
  send_CMD_ACK(0x64,0x11,0); //表示擦除失败，需要重新擦除
  注意：上位机必须收到擦除成功的响应，才能进行下一步
```

Step 5: Send Upgrade Data Packet

After successful erasure, the most critical step of sending firmware data begins. Data transmission uses the function Send_Upload_Data. PC software splits the upgrade firmware into packets, each with a fixed size of 64 bytes; the last packet is sent according to its actual byte count if less than 64 bytes. Each frame contains the valid data length and this packet's offset address within the entire firmware. PC software For each frame sent, it is necessary to wait forIMU the module's response to determineIMU that the current frame has been successfully received before sending the next frame. IMU After the module successfully receives the data packet from PC software, it sends response data and writes to the specified flash address based on offset address.

If the flash write fails, a failure command is sent; if the write succeeds, no command is sent.

```
例：将大小 1000 字节的升级文件 uint8_t Upgrade_Data[1000]发送给 imu 模块
 //发送第一包：
  1.1 通过函数将 0~63 字节发送到 imu 模块
  Send_Upload_Data（0x27,0,0,0x40,Upgrade_Data);
  //上面函数第一参数 0x27 为固定值，第二参数 0 为固定值，第三参数 0 为偏移地址，
    第四参数 0x40 为有效字节长度，第五参数为发送数据的首地址

 1.2 imu 成功收到数据后，会发送响应数据，并根据偏移地址写入指定的 flash 地址
   send_CMD_ACK(0x753D,0x00,0);
   //上面函数第一参数 0x753D 为固定值，第二参数 0 为固定值，第三参数为偏移地址。
   imu 模块将数据写入 flash 过程中如果写入失败将发送失败命令 send_CMD_ACK(0x64,0x11,0);

  //发送第二包：
   2.1 上位机收到 imu 响应数据后，将发送第二包数据 Send_Upload_Data（0x27,0,0x40,0x40,Upgrade_Data+0x40);
   2.2 imu 成功收取到第二包数据后，发送响应： send_CMD_ACK(0x753D,0x00,0x40);
   2.3 imu 模块将数据写入 flash 过程中如果写入失败将发送失败命令 send_CMD_ACK(0x64,0x11,0);



  //发送第三包
   3.1 上位机收到 imu 响应数据后，将发送第三包数据 Send_Upload_Data（0x27,0,0x80,0x40,Upgrade_Data+0x80);
   3.2 imu 成功收取到第三包数据后，发送响应： send_CMD_ACK(0x753D,0x00,0x80);
   3.3 imu 模块将数据写入 flash 过程中如果写入失败将发送失败命令 send_CMD_ACK(0x64,0x11,0);

  //发送第十五包：
```

```
   15.1 上位机收到 imu 响应数据后，将发送第十五包数据 Send_Upload_Data（0x27,0,0x380,0x40,Upgrade_Data+0x380);
   15.2 imu 成功收取到第十五包数据后，发送响应： send_CMD_ACK(0x753D,0x00,0x380);
   15.3 imu 模块将数据写入 flash 过程中如果写入失败将发送失败命令 send_CMD_ACK(0x64,0x11,0);
  //发送第十六包：
   15.1 上位机收到 imu 响应数据后，将发送第十六包数据 Send_Upload_Data（0x27,0,0x3C0,0x28,Upgrade_Data+0x3C0);
   15.2 imu 成功收取到第十六包数据后，发送响应： send_CMD_ACK(0x753D,0x00,0x3C0);
   15.3 imu 模块将数据写入 flash 过程中如果写入失败将发送失败命令 send_CMD_ACK(0x64,0x11,0);
  发送结束
```

Step 6: Obtain **CRC** Checksum

In general, the firmware upgrade command format is imu614e-b#CRC1373387121.firmware, where the CRC string is immediately followed by the pre-calculated CRC checksum value. After sending the upgrade file, the host software must send a verification command to check whether the upgrade file received by the IMU module is correct. After PC software sends the Send_CMD_LONG(0x29,0,0,0,0,0,0) command, it retrieves the CRC check digit calculated by the IMU module itself.

If PC software determines that CRC checksum value is incorrect, the upgrade process should be restarted from Step 4 (Send Erase Command).

```
  上位机发送获取 crc 校验码指令，等待 imu 响应
   Send_CMD_LONG(0x29,0,0,0,0,0,0);
  imu 模块响应发送 crc 校验值数据：
  send_CMD_ACK(0x753C,0x10,crc32_data);
   其中 crc32_data 值为 imu 模块本身计算的 crc32 数据
```

Step 7: Send Restart Command

InPC software After verifying that the CRC checksum is correct, send the reboot command to complete the upgrade.

```
判断 crc 校验值正确后，发送重启命令：
 Send_CMD_LONG(0x30,0,0,0,0,0,0);
```

After the firmware update is complete, power cycle the device and read the version number to verify if the update was successful.

Function Definition:

1. The definition of the Send_CMD_LONG function is as follows:

```
struct  MULTI_LONG_CMD_STRUCT
{
uint8_t header1;
uint8_t header2;
uint16_t id;
uint16_t length;
float  param1;
float  param2;
uint32_t param3;
uint32_t param4;
int32_t param5;
int32_t param6;
uint32_t check_crc;
}__attribute__((packed));
```

```
void  :Send_CMD_LONG(uint16_t cmd_id,float cm1,float cm2,uint32_t  cm3,uint32_t cm4,int32_t  cm5,int32_t cm6)
{
    uint8_t check_sum=0;
    struct MULTI_LONG_CMD_STRUCT data_cmd_long __attribute__((packed));
    data_cmd_long.header1=0x55;
    data_cmd_long.header2=0xAA;
    data_cmd_long.id=cmd_id;
    data_cmd_long.length=sizeof(data_cmd_long)-10;
    data_cmd_long.param1=cm1;
    data_cmd_long.param2=cm2;
    data_cmd_long.param3=cm3;
    data_cmd_long.param4=cm4;
    data_cmd_long.param5=cm5;
    data_cmd_long.param6=cm6;
    int len=sizeof(data_cmd_long)-4;
    uint32_t check_crc=1;
    data_cmd_long.check_crc=crc_crc32(check_crc,(uint8_t *)(&data_cmd_long), len);
    send((uint8_t *)(&data_cmd_long),sizeof(data_cmd_long));
}
```

2. The definition of the Send_CMD_ACK function is as follows:

```
struct  CMD_ACK_STRUCT
{
uint8_t header1;
uint8_t header2;
uint16_t id;
uint16_t length;
uint32_t command;/*<   Command ID (of acknowledged command).*/
uint32_t result;/*<   Result of command.*/
uint32_t check_crc;
}__attribute__((packed));

void Send_CMD_ACK(uint16_t cmd_id,uint16_t ack_id,uint32_t result)
{
    uint32_t check_crc=0;
    struct CMD_ACK_STRUCT data_cmd_ack __attribute__((packed));
    data_cmd_ack.header1=0xAA;
    data_cmd_ack.header2=0x55;
    data_cmd_ack.id=cmd_id;
    data_cmd_ack.length=sizeof(data_cmd_ack)-10;
    data_cmd_ack.command=ack_id;
    data_cmd_ack.result=result;
    int len=sizeof(data_cmd_ack)-4;
    check_crc=1;
    data_cmd_ack.check_crc=crc_crc32(check_crc,(uint8_t *)(&data_cmd_ack), len);
    Cout((uint8_t *)(&data_cmd_ack),sizeof(data_cmd_ack));
}
```

The definition of the Send_Upload_Data function is as follows:

```
struct  UPLOAD_DATA
{
uint8_t header1;
uint8_t header2;
uint16_t id;
uint16_t length;
uint8_t param[64];
uint32_t offset;
uint16_t size;
uint8_t cmd;
uint32_t check_crc;
}__attribute__((packed));

struct UPLOAD_DATA  upload_data;
void Send_Upload_Data(uint8_t cmd_id,uint8_t cmd,uint32_t offset,uint16_t size,uint8_t*  param)
{
    upload_data.header1=0x55;
    upload_data.header2=0xAA;
    upload_data.id=cmd_id;
    upload_data.length=sizeof(UPLOAD_DATA)-10;
    upload_data.cmd=cmd;
    for(int i=0;i<size;i++)
    upload_data.param[i] = *(param+i);
    upload_data.offset=offset;
    upload_data.size=size;
    int len=sizeof(UPLOAD_DATA)-4;
    uint32_t check_crc=1;
    upload_data.check_crc=crc_crc32(check_crc,(uint8_t *)(&upload_data), len);
    send((uint8_t *)(&upload_data),sizeof(UPLOAD_DATA));
}
```

4. The CRC32 checksum function is as follows:

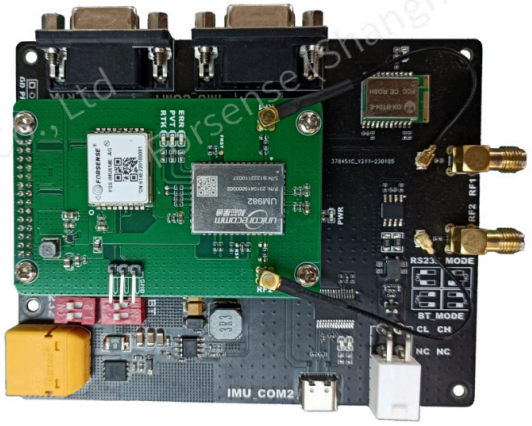
```
static const uint32_t crc32_tab[] = {
    0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419, 0x706af48f,
    0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4, 0xe0d5e91e, 0x97d2d988,
    0x09b64c2b, 0x7eb17cbd, 0xe7b82d07, 0x90bf1d91, 0x1db71064, 0x6ab020f2,
    0xf3b97148, 0x84be41de, 0x1adad47d, 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,
```

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11. Test Base Plate User Guide

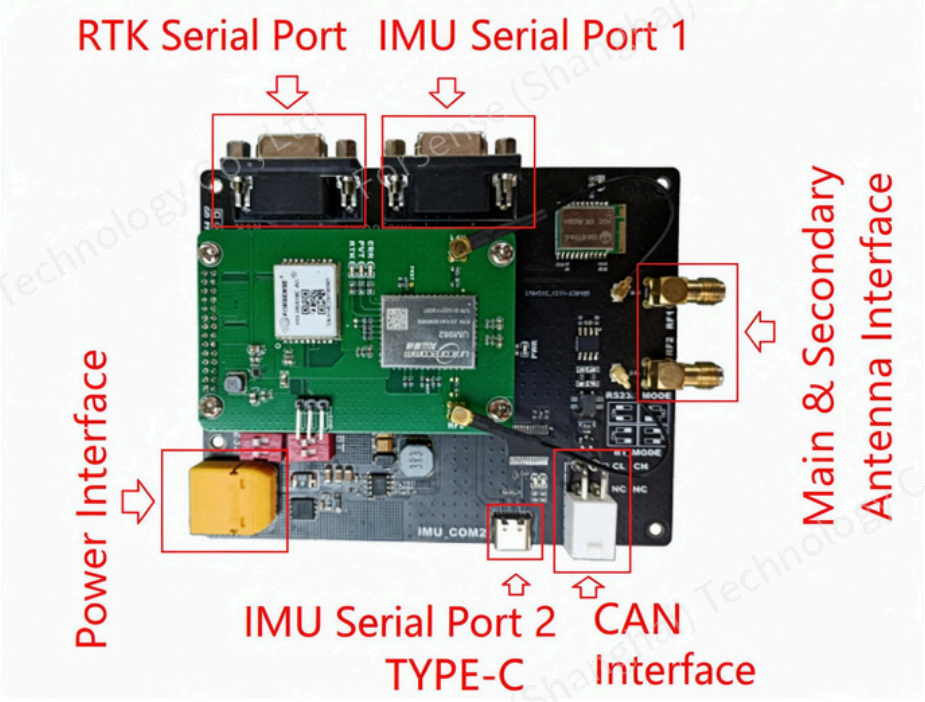
11.1 Physical Diagram

Figure 16 Physical Schematic Diagram



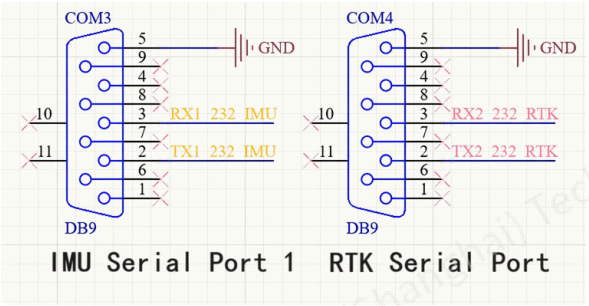
11.2 Interface Diagram

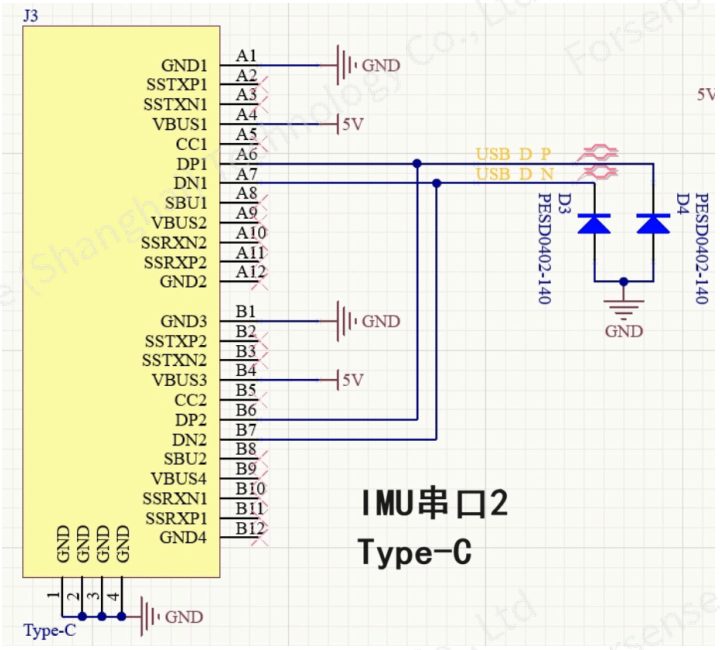
Figure17 Interface Diagram



11.3 Interface Definition

Figure 18 Interface Definition





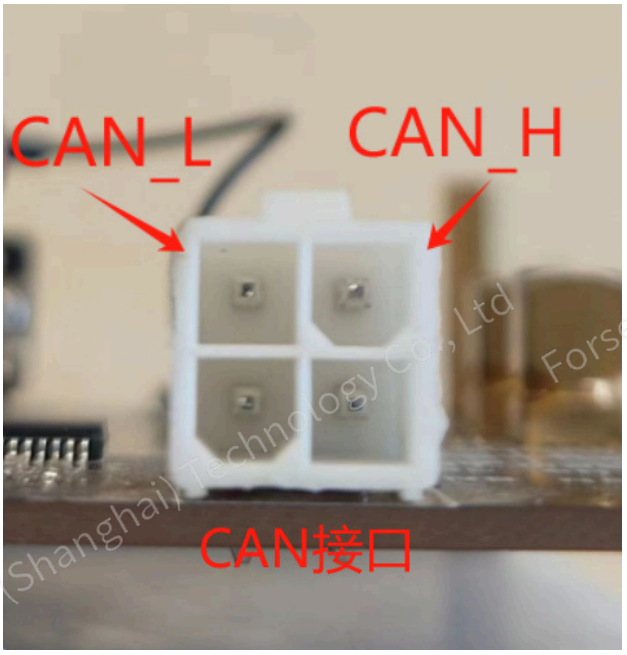
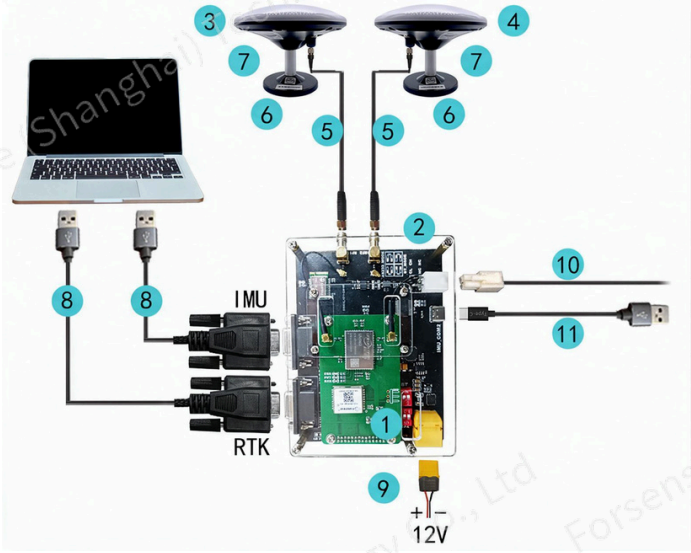


Figure19 Test Base PlateConnection Diagram



	Name	Quantity
1	FS982-AG Integrated Navigation Board	1 pc
2	FS982 Test Base Plate	1 pc
3	Primary antenna (positioning antenna)	1 pc
4	Secondary antenna (Directional Antenna)	1 pc
5	Antenna feeder	2 pcs
6	Antenna Suction Cup	2 pcs
7	Antenna Mast	2 pcs
8	USB to RS232 Cable Assembly	2 pcs
9	XT60 Power Connector (12V Supply)	1 pc
	Accessory Name	Quantity
10	CAN Interface (Connector Model EL-4PIN)	User Fabricated
11	Type-C Data Cable	User Provided

11.4 Interface Description

IMU Serial Port 1 and IMU Serial Port 2 cannot be configured separately. After sending the configuration command, both Serial Port take effect simultaneously and output the same data stream.

11.4.1 RTK Serial Port

Interface Type: Serial Port (DB9);

This interface is internally connected to RTK Serial Port 2, used for receiving RTK data, importing differential data, and configuring RTK Parameter;

11.4.2 IMU Serial Port 1

Interface Type: Serial Port (DB9);

This interface is internally connected to IMU Serial Port 1, used for connecting PC software, reading IMU data, and modifying IMU Parameter;

11.4.3 Main Secondary antenna Interface

Interface Type: SMA RF Interface;

This interface internally connects to the RTK Main Unit (RF1) and Secondary antenna (RF2);

This interface internally connects to

11.4.4 CAN Interface

Interface Type: CAN;

This interface internally connects to the IMU's CAN port, used for receiving data from the front wheel angle gyroscope G200 and outputting via CAN protocol;

11.4.5 IMU Serial Port 2

Interface Type: Serial Port (type-C);

This interface internally connects to IMU Serial Port 2, which can be used to connect to PC software, read IMU data, modify IMU Parameter, and power the test Base Plate (5V);

11.4.6 Power Interface

Interface Type: XT60;

This interface is used to power the FS982-AG test Base Plate;

supply voltage:12V±0.3V.

12. ROS Driver

ROS Driver Download URL:https://data.forsense-imu.com/page/download.html



12.1 Install ROS serial

Install the ROS serial package. This example relies on the serial package provided by ROS to implement serial communication.

First, execute the following command to download and install the serial package:

sudo apt-get install ros -melodic-serial

Then enter roscd serial command to enter the serial download location. If the installation is successful, the following will appear:

the following information:

/opt/ros/melodic/share/serial

12.2 Compile Code

cd FS982_ros/

catkin_make

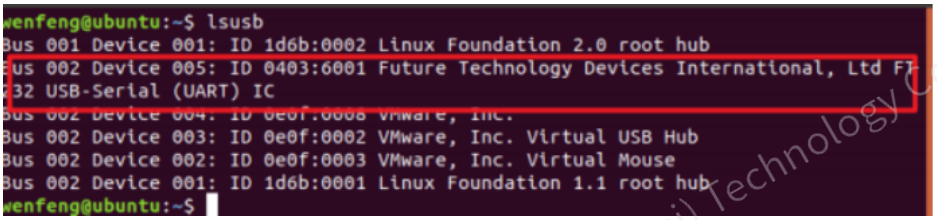
[图片加载失败]

Compilation Complete

12.3 Connect the IMU to the system via USB

Check if connected:

lsusb



Check USB port number:

ls /dev/ttyU*



Configure to open USB to serial port privileges:

sudo chmod 777 /dev/ttyUSB0

12.4 View Data

Run roscore to start ROS

Return to the serial_imu_ws folder and run

source devel/setup.bash

Run rosrun to launch

rosrun forsense_ins forsense_ins

```
wenfeng@ubuntu:~/nav619_ros1$ rosrun forsense_ins forsense_ins
[ INFO] [1695457979.128623440]: /dev/ttyUSB0 is opened.
```

Open a new window

source devel/setup.bash

rostopic list

```
wenfeng@ubuntu:~/nav619_ros1$ rostopic list
/nav619Data
/rosout
/rosout_agg
```

Enter command to view IMU data

rostopic echo /FS982Data

```
  frame_id: "WGS84"
itow: 549636980
week_num: 2280
lat: 312627286
lon: 1216155393
hgt: 38859
vn: 0.00240602344275
ve: 0.000262897461653
vd: 0.00270945159718
roll: -0.169113516808
pitch: -0.286453634501
yaw: 0.0
rtk_yaw: 359.766906738
wheel_angle: 0.0
imu: [-0.005366197787225246, 0.0035326573997735977, -1.004271149635315, -0.04756
217822432518, -0.11066819727420807, -0.06515973061323166, 35.8017578125]
fix_type: 16
sv_num: 28
diff_age: 0
heading_type: 0
pos_acc: 0
status: 3
---
```

13. Used with G200

1. Installation Requirements for G200:

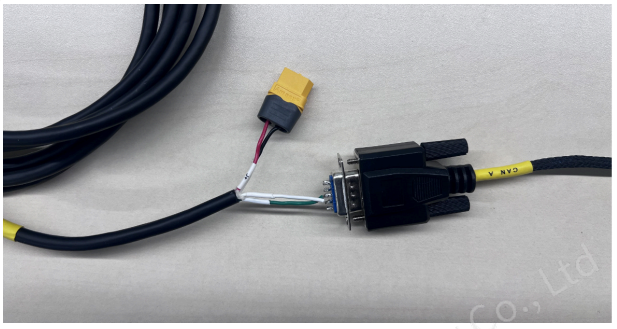
A. G200 must be installed on the front axle of the front wheel (a horizontal rigid position that rotates with the front wheel)

B. Install G200 with the cable outlet pointing toward the rear of the vehicle

2. Connect the CAN interface of G200 to CAN A of the harness; power supply is 5V

Figure20 Wiring Diagram

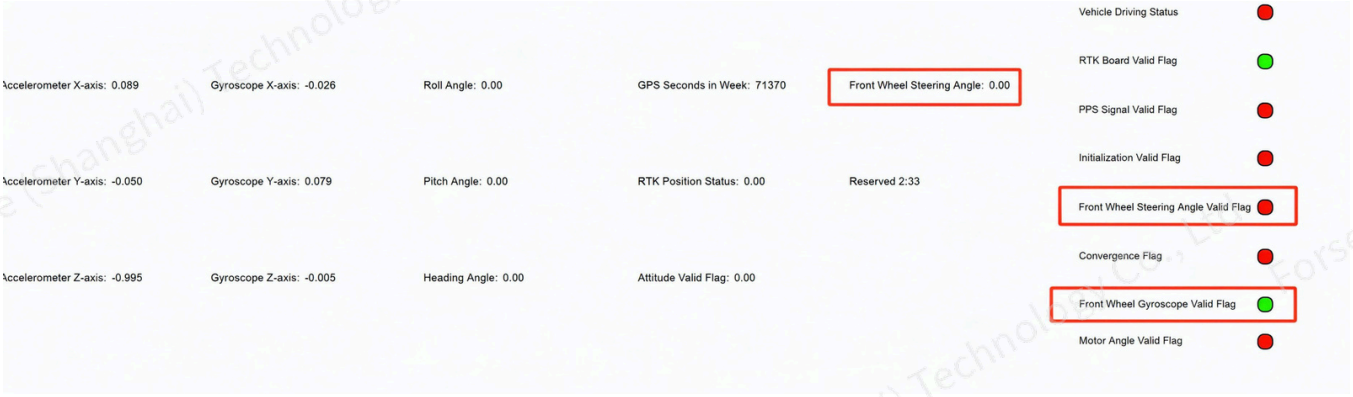




3. First, measure the vehicle's wheelbase. Taking a 2 m wheelbase as an example, connect Master's Serial Port to the Serial Port Assistant, send AT+WHEEL_BASE=2, receive the response WHEEL_BASE=2, then send the save command AT+SAVE, receive the response OK, and power cycle the device.

4. Connect the device to FS982-AG, decode PC software V3.3.4, enter the homepage of PC software, select port Serial Port, set baud rate (default 115200), click Connect. If the device information on the left is displayed, the connection is successful. Click Mode Start in the lower-left corner. When G200 is correctly connected, the front wheel gyroscope significant bits displays green.Otherwiseit displays red. After vehicle initialize succeeds, the front wheel steering angle significant bits displaysasgreen; otherwiseit displays red. Once the vehicle moves, front wheel steering angle data is output in real time.

Figure21 G200 Correct Connection Diagram



14. OptionalProduct

	
FS982-AG Base Plate Test	RS232 Serial Port Cable
	
Type-C Cable	USB-to-CAN Module

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Primary antenna(positioning antenna)	Secondary antenna (Directional Antenna)
	
Primary antenna Connection Cable	Secondary antenna Connection Cable



G200

15. FAQs List

Table 17 FAQs Table

Issue	Solution
PC software cannot connect	Please check if Serial Port is occupied and whether the product is properly powered on. If PC software disconnects during the connection process, it may be due to a loose Serial Port. Try unplugging and replugging the Serial Port cable, then reopen PC software.
Positioning Status is Always 1	Verify that differential data is properly connected and check if parameters such as baud rate, differential account, and mount point are correct.
Dual antenna Orientation status never reaches 50	Please troubleshoot the following factors: 1. If Orientation status remains 0, check whether Secondary antenna is correctly connected and whether antenna feeder is damaged. 2. If Orientation status is not 0 but never reaches 50, ensure the test environment is open and verify that the distance of Dual antenna is greater than 50 cm.
Signal is normal when connected to active antenna, but no signal when connected to passive antenna.	The distance between passive antenna and feeder must not exceed 1.5 m.
Signal is normal when the antenna is connected to active power splitter, but no signal when the device powers the antenna.	Check if there are issues with the antenna feeder, such as short-circuited or electrostatic discharge caused by plugging/unplugging the antenna during power-on, which may lead to abnormal antenna power supply circuits. The current circuit design includes a fuse; restoring power can resolve this issue.
Unable to initialize	initialize requires the following conditions: single antenna: Positioning status fixed solution + driving speed above 0.5 m/s + straight-line driving with acceleration and deceleration Dual antenna: Positioning status fixed solution + Orientation status 50
Serial Port packet loss	Please troubleshoot the following factors: (1) The Serial Port cable must support a baud rate of at least 115200. (2) The PC Serial Port delay must be configured to 2 ms.
How to determine if the physical connection of G200 is correct	Parse the value of Status bits to check if bit5 is valid
With G200 connected, the front wheel gyroscope significant bits is invalid	Use a CAN analyzer to verify that the CAN baud rate of G200 matches that of AG. If they do not match, adjust them to be consistent. Refer to the Parameter configuration page in the G200 and AG manuals for specific commands.
With G200 connected, the front wheel gyroscope significant bits is valid, but the front wheel angle is abnormal	Please troubleshoot the following factors: (1) The prerequisite for correct front wheel angle output is that the AG device must complete initialize before it can output the correct front wheel angle. (2) Check if the wheelbase is configured; an unconfigured wheelbase will cause the front wheel steering angle to be invalid.
After configuring the CAN lever arm and Dual antenna angle information, the results do not match the configuration	Check if the configuration follows these guidelines: little-endian mode, little-endian format, unit in CM, negative numbers require two's complement
Can NMEA protocol and binary protocol be output synchronously?	Not supported; only one of the protocols can be output at a time.
With G200 connected, the front wheel steering angle is asymmetric when turned fully left or fully right.	Please troubleshoot the following factors: 1. Check if G200 is installed horizontally. 2. If powered on only while stationary, power on at 0 degrees, or drive straight manually for a short distance to correct it.
Why is there still a satellite count when the antenna is disconnected?	UM982 has strong signal tracking capability. If there are signal sources nearby, it will continue to track for a period via coupling even with the antenna disconnected. In actual satellite loss-of-lock scenarios, the antenna remains connected and external signals cannot enter, so usage is not affected.
Using a metal pot lid to block the antenna to simulate loss of lock, the status remains fixed solution	Incorrect testing method: A metal pot lid only blocks signals from directly above. Side signals reflect off the vehicle roof onto the bottom of the lid and then back to the antenna, causing a false fix phenomenon.
ROS driver fails to read data	The device is not configured to output the combined data stream by default upon power-on. Configuring the default combined data output on power-on resolves this issue.
Large Heading Error	Possible causes include: 1. Incorrect lever arm or wheelbase configuration; units may be scaled up by a factor of 10. 2. Verify if the installation is rigidly fixed. 3. Check if the device is located away from strong vibration sources.
Attitude error relative to the reference exceeds the limit	Verify whether installation errors are subtracted during statistics (typically, the mean error relative to the reference is considered the installation error)
How to perform two's complement operations when configuring CAN commands in little-endian mode	Two's complement applies to negative numbers. For -20: X - 65536 = -20, so X = 65516. The hexadecimal value of 65516 is FFEC, and that of 65535 is FFFF. Since counting starts from 0, the maximum value is 65536; subtracting this maximum from the current result yields the two's complement value

16. Update Records

Latest Manual Version: FS982-AG_Datasheet_Product Manual（en）

Version	Date	Status/Notes
Version 1.0	2023.07.08	Initial Release
Version 1.1	2023.10.07	Updated Coordinate System Definition
Version 1.2	2023.12.14	Added Attachments
Version 1.3	2024.01.18	1. Added NMEA Sentence Data Stream Configuration Command 2. Added Installation Rotation Angle Configuration Command 3. Added test Base Plate description
Version 1.4	2024.01.18	1. Added ROS driver description 2. Added PC software usage instructions
Version 1.5	2024.01.25	Added test Base Plate interface definition
Version 1.6	2024.02.21	Added PPS accuracy description
Version 1.7	2024.02.22	Corrected the description of the rotation angle configuration response
Version 1.8	2024.03.22	Updated installation diagrams
Version 1.9	2024.03.26	Added description for slope mode usage with G200
Version 2.0	2024.04.09	Added calibration for Dual antenna
Version 2.1	2024.06.12	1. Added some new AT commands 2. Added CAN protocol latitude/longitude and Elevation messages 3. Added FAQs list
Version 2.2	2025.01.23	Adjusted table and figure numbering
Version 2.3	2025.12.31	Added CAN commands