BS-NU23-M-D6EC

Integrated Navigation System

Instructions for use

Update the record

Serial number	Version	Change the date	Before the change	After the change	Reason for the change	Changed by
1	V1.00	20190605			New establishment	
2	V1.01	20190616		Add appearance diagram		
3	V1.02	20190814		Add technical indicators Add Output Lever Arm Settings Increase the setting of the mounting angle		
4	V1.03	20191125		Add bdpdb protocol description		
5	V1.04	20191202		Add output protocol description Add the configuration description of satellite board		
6	V1.05	20191216		Added description of differential configuration		
7	V1.06	20191217		Added Pure Inertia Test Description		
8	V1.07	20200227	Combined attitude accuracy 0.3 °	0.1°		
9	V1.08	20200229		Add opening position smooth caution		
10	V1.09	20200305	Postprocessing attitude accuracy 0.3 °	0.02°		
11	V1.10	20200318	RTK Position Accuracy 5cm + 1 ppm	2cm+1ppm		
12	V1.11	20200325		Increase GNSS failure horizontal position accuracy		
13	V1.12	20200723		Increase the output angle setting		
14	V1.13	20200804		Add protocol checksum description	Perfect	

1. Overview

BS-NU23-M-D6EC integrated navigation system consists of MEMS IMU and high-end GNSS receiver board, which is realized by multi-sensor fusion and navigation algorithm. The product has high reliability and strong environmental adaptability. By matching different software, the product can be widely used in UAV, UAV, surveying and mapping, marine compass, stable platform, underwater vehicle and other fields.

2. Functions and indicators

2.1 Main functions

The integrated navigation system can use the satellite navigation information received by the GNSS receiver to carry out integrated navigation and output the information of the carrier, such as pitch, roll, course, position, speed, time and the like; After losing the signal, it outputs the position, velocity and attitude information of inertial solution, and has a certain navigation accuracy maintenance function in a short time. When combined with navigation, it can output the raw information that can be used for post-processing to be processed by the IE post-processing software of NovAtel.

2.2 Performance index

The system performance is shown in Table 1.

Table 1 System Performance Requirements

Project		Indicators
Heading accuracy	Dual GNSS (2m baseline)	0.1°（RMS）
	Single GNSS	0.2°（RMS）
	Post-processing	0.03°（RMS）

Project		Indicators
	Course keeping (GNSS failure)	1°/min（RMS）
Attitude accuracy	GNSS valid (single point L1/L2)	0.1°（RMS）
	Inertia/odometer combination (optional)	0.1°（RMS）
	Post-processing	0.02°（RMS）
	Hold (GNSS failure)	1°/min（RMS）
Horizontal positioning accuracy	GNSS valid, single point L1/L2	1.2m（RMS）
	Inertia/odometer combination (optional)	2 ‰ D (D represents mileage, CEP)
	RTK	2cm+1ppm（RMS）
	Post-processing	1cm+1ppm（RMS）
	GNSS failure	1m/10s、10m/30s、20m/60s（RMS）
Horizontal velocity accuracy	GNSS valid, single point L1/L2	0.1m/s（RMS）
	Inertia/odometer combination (optional)	0.1m/s（RMS）
	Inertial/DVL combination (optional)	0.2m/s（RMS）
Gyroscope	Measuring range	±450°/s
	Zero bias stability	3°/h
Accelerometer	Measuring range	±16g
	Zero bias stability	30μg
Communication interface	RS422 /RS232	Route 7
	CAN (optional)	Route 1 Baud rate up to 1Mbps Transmitting frequency up to 200Hz
	Ethernet interface	10M
	Odometer differential input (optional)	Route 2
	PPS	Route 1
	EVENT	Route 1
Electrical characteristics	Voltage	9~36VDC
	Power consumption	≤10W
	Built-in memory (optional)	16G
Structural characteristics	Size	117mm×96mm×47.8mm
	Weight	≤0.7kg
Use environment	Operating temperature	-40℃~+60℃
	Storage temperature	-45℃~+65℃
	Vibration	5~2000Hz，2g
	Impact	30g，11ms
Reliability	MTBF	30000h

Project		Indicators
	Life span	> 15 years
	Continuous working time	>24h

3. How it works

3.1. Product composition

The composition of the product is shown in Figure 1.

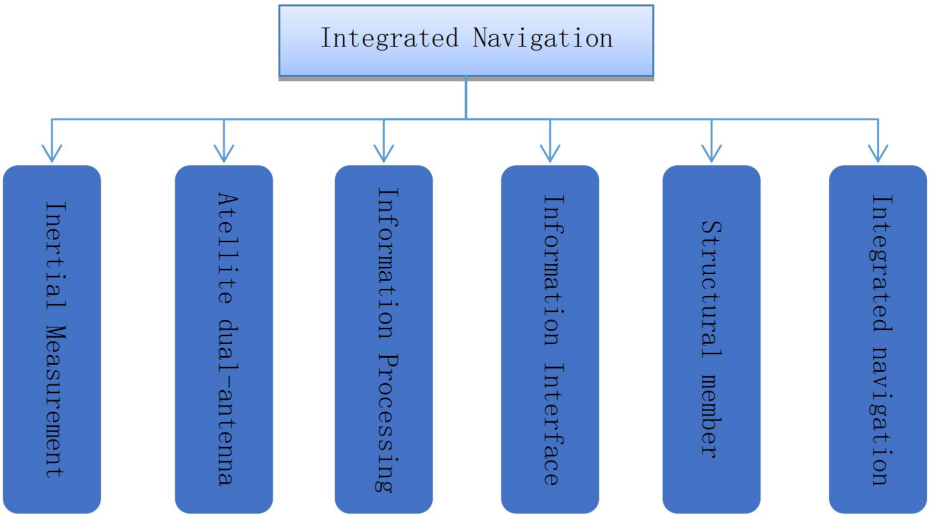

Figure 1 System composition

3.2. Basic principles

The inertial measurement unit consists of three accelerometers and three gyroscopes and is used for measuring the acceleration and the angular velocity of a carrier and sending the information to the information processing circuit; and the information processing circuit performs navigation settlement by using the acceleration and the angular velocity measured by the inertial measurement unit, and simultaneously receives satellite navigation information of a GNSS receiver as a reference to perform combined navigation, The navigation error of the inertial navigation is corrected, and the navigation information is output through the information interface circuit.

The basic principle is shown in Figure 2.

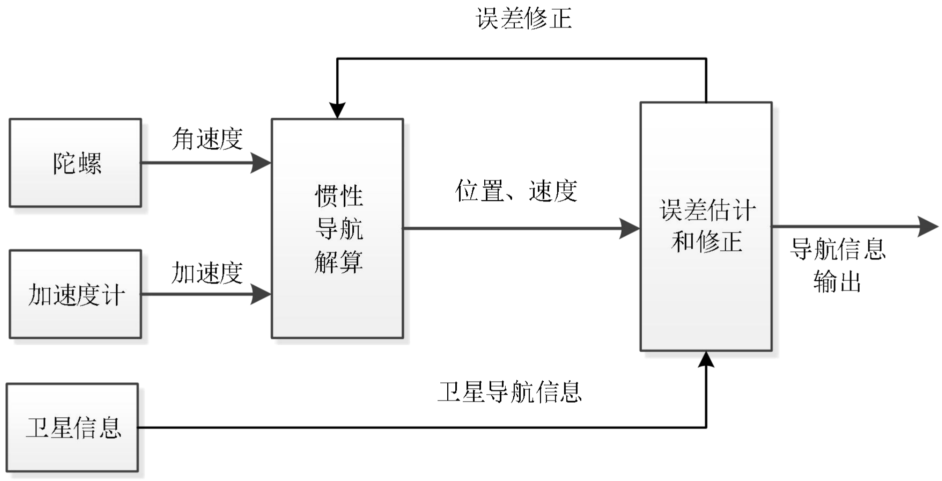

Fig. 2 Schematic diagram of working principle

4. Instructions for use

4.1 Overall dimension

The inertial measurement unit and GNSS receiver adopt an integrated design scheme and are integrated in the integrated navigation system. The outline of the system is shown in Figure 3.

The overall dimension of the system is 117mm × 96mm × 47.8mm (length × width × height).

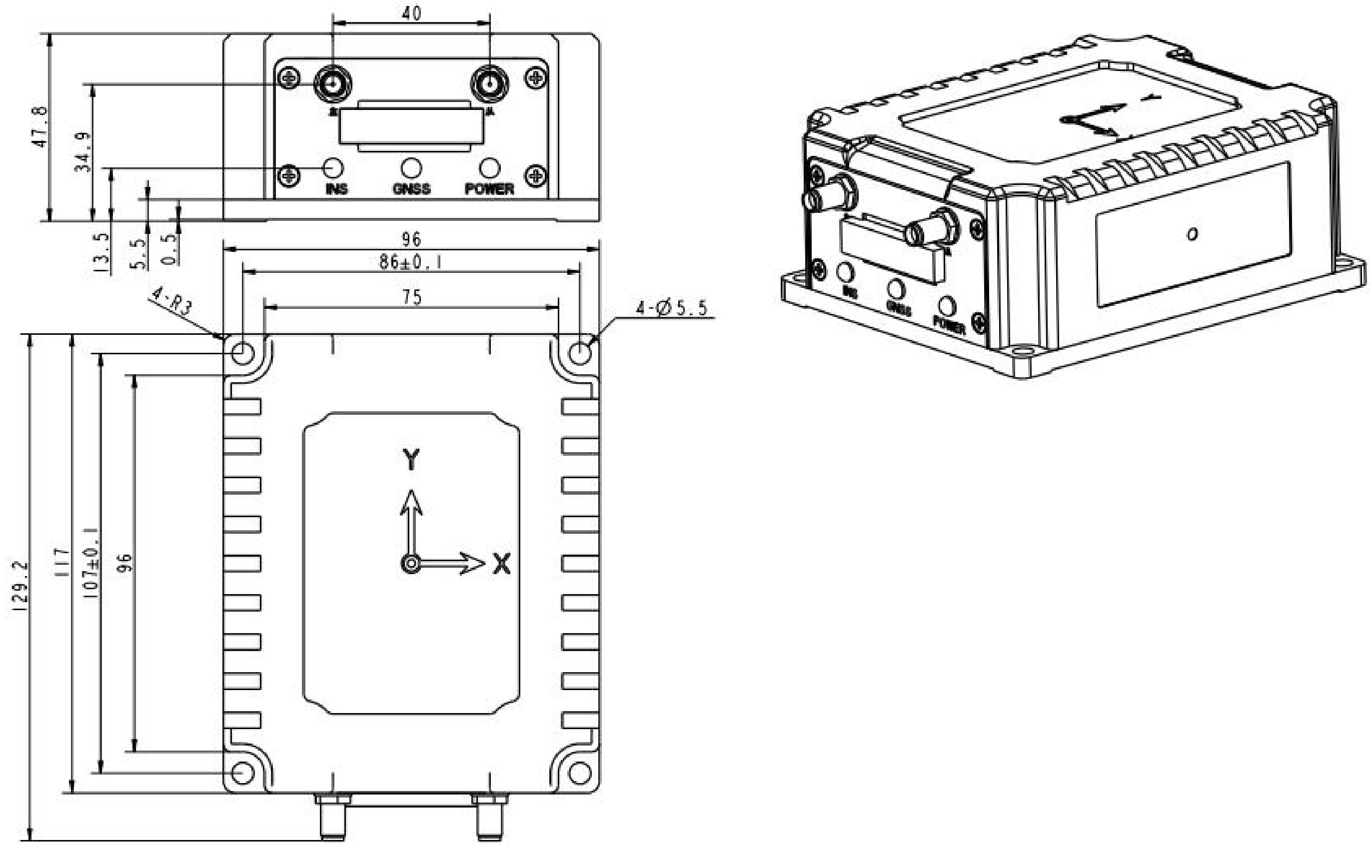

Fig. 3 Outline structure of integrated navigation system

4.2 Electrical interface

The system has 3 external connectors:

a) A communication interface

b) Two RF line interfaces (SMA outer screw inner hole, where the left is connected to the main antenna, the right is connected to the slave antenna, and the left and right are defined by facing the interface)

One end of the communication cable is a J30J connector, which is connected to the system, and the other end is divided into a power line and a communication line (except that the network line is 0.5m long, other interface lines are 1.5m long):

a) Power cable: connected to 9 ~ 36 V DC, the working current is not more than 0.4A when the power supply is 24 V, the external wire is thrown, and the red and black clips are connected.

b) Communication cable: with 7 serial ports, 1 Ethernet interface, 1 CAN interface, PPS interface, EVENT interface and odometer interface. COM1 is used to send working mode instructions, which is RS232; COM2, COM3 and COM4 are protocol output interfaces, which are RS232 and RS422 configurable; COM5 is used for product debugging, which is RS232; GNSS _ COM 1 and GNSS _ COM3 are directly connected to COM1 and COM3 of GNSS receiver board; Serial ports are all BD 9 female. CAN interface, PPS interface, EVENT interface and odometer interface are connected out in a line-throwing mode.

c) Two RF cables: one end is connected to the antenna, and the other end is connected to the product.

The external connector points are defined in Table 2.

Table 2 J30J (J30J-51ZKWP7-J) Connector Point Definition

J30J Point No	Signal definition	Identification	Handling method	Remark
1	IN1	IN1+	Throw the line	The first road odometer
2	IN1_GND	IN1-	Throw the line	
3	IN2	IN2+	Throw the line	The second way odometer
4	IN2_GND	IN2-	Throw the line	
6	GNSS_EVENT2	617_EVENT2	Throw the line	
7	GNSS_PPS	617_PPS	Throw the line	
8	GNSS_GND	GND	Throw the line	
9	COM1_RXD	COM1	1-DB 9 holes: 3	RS232
10	COM1_TXD		1-DB 9 holes: 2	
11	COM1_GND		1-DB 9 holes: 5	
14	COM2_RS422_TXD_P	COM2	2-DB 9 holes: 6	RS422/RS232 Default RS 232
15	COM2_RS422_TXD_N/RS232T		2-DB 9 holes: 2	
17	COM2_RS422_RXD_P/RS232R		2-DB 9 holes: 3	

J30J Point No	Signal definition	Identification	Handling method	Remark
16	COM2_RS422_RXD_N		2-DB 9 holes: 8	
18	COM2_GND		2-DB 9 holes: 5	
35	COM3_RS422_TXD_P	COM3	6-DB 9 holes: 3	RS422/RS232 RS422 is the default
34	COM3_RS422_TXD_N/RS232T		6-DB 9 holes: 4	
51	COM3_RS422_RXD_P/RS232R		6-DB 9 holes: 1	
50	COM3_RS422_RXD_N		6-DB 9 holes: 2	
36	COM3_GND		6-DB 9 holes: 5	
48	COM4_RS422_TXD_P	COM4	7-DB 9 holes: 3	RS422/RS232 RS422 is the default
47	COM4_RS422_TXD_N/RS232T		7-DB 9 holes: 4	
46	COM4_RS422_RXD_P/RS232R		7-DB 9 holes: 1	
45	COM4_RS422_RXD_N		7-DB 9 holes: 2	
44	COM4_GND		7-DB 9 holes: 5	
19	24V_GND	24V_GND	Black alligator clip	Power supply
20	24V_GND			
21	24V	24V	Red alligator clip	
22	24V			
23	GNSS_COM3_RXD_RS232	GNSS_COM3	3-DB 9 holes: 3	RS232
24	GNSS_COM3_TXD_RS232		3-DB 9 holes: 2	
25	GNSS_COM3_GND		3-DB 9 holes: 5	
26	GNSS_COM1_TXD_RS232	GNSS_COM1	4-DB 9 holes: 2	RS232
27	GNSS_COM1_RXD_RS232		4-DB 9 holes: 3	
28	GNSS_COM1_GND		4-DB 9 holes: 5	
29	TEST_COM_RS232_TXD	COM5	5-DB 9 holes: 2	Debugging port, RS232
30	TEST_COM_RS232_RXD		5-DB 9 holes: 3	
31	TEST_COM_GND		5-DB 9 holes: 5	
37	ETHER_RX_N（2）	Ethernet	RJ45-6(NET)	10 M Ethernet interface
38	ETHER_RX_P（1）		RJ45-3(NET)	
39	ETHER_TX_N（6）		RJ45-2(NET)	
40	ETHER_TX_P（3）		RJ45-1(NET)	
41	CAN_GND	CAN	Throw the line	CAN
42	CAN_P		Throw the line	
43	CAN_N		Throw the line	
49	GND			

4.3 Instructions for use

4.3.1 System workflow

4.3.1.1 Startup Prompt

Connect the cable, power on the system, monitor the COM1 interface information through the serial port debugging tool of the test computer, and display "" on the interface for Please enter NaviMode within 20s! "", you can send workflow instructions to the COM1 interface through the serial debugging tool. " # moddgi "is the work instruction for entering the integrated navigation;" # modins "is the work instruction for entering the inertial navigation. If no command is sent within 20 s, the system will automatically enter the integrated navigation workflow after 20 s.

After entering the integrated navigation process, the satellite information is bound first, and if the satellite is not positioned, it is in the state of waiting for the satellite information; When the satellite information is valid, the system enters the alignment state, the alignment time is 10s, and the integrated navigation system is required to be static during the alignment period; After the alignment is completed, the integrated navigation system can move, and the system is in an integrated navigation state.

After entering the inertial navigation process, the satellite information is bound first, and if the satellite is not positioned, it is in the state of waiting for the satellite information; When the satellite information is valid, the system enters the coarse alignment state, the coarse alignment time is 10s, and the integrated navigation system is required to be static during the coarse alignment; After the coarse alignment is completed, the integrated navigation system can move, and the system is in a fine alignment state; After fine alignment for 1500 s, it will automatically switch to the inertial navigation state.

4.3.1.2 System reset

During operation, input the "# reset" command, and the system will perform soft reset and display the startup information again.

4.3.1.3 Export of stored data

This product is equipped with optional data storage function. If it is equipped with data storage function, the total storage space is 16g. After the system completes the coarse alignment, the system automatically saves the storage information according to the user's configuration. The name of the saved data folder is recordX, where X is the file number (up to 39), and the number increases in turn. When X is 39, record00 is automatically overwritten in the next storage, and X still increases in turn in the next storage. If the system is configured to store data, the system will automatically delete the oldest data folder after each power-on operation. For example, if the currently generated file is record08, there will be no record09 folder in the system memory. Users can use this as a basis to find the latest data file.

The recordX folder contains various protocol files configured by the user. Each protocol is a separate file, and the file name is the protocol name.

The data export operation is as follows:

a) Connect the Ethernet interface to the test computer;

b) Set the IP address of the test computer as 192.168.1.22;

c) Power on the system;

d) Run SSH software (SSH Secure File Transfer Client);

e) Click Quick Connect and fill in the contents as shown in Figure 4;

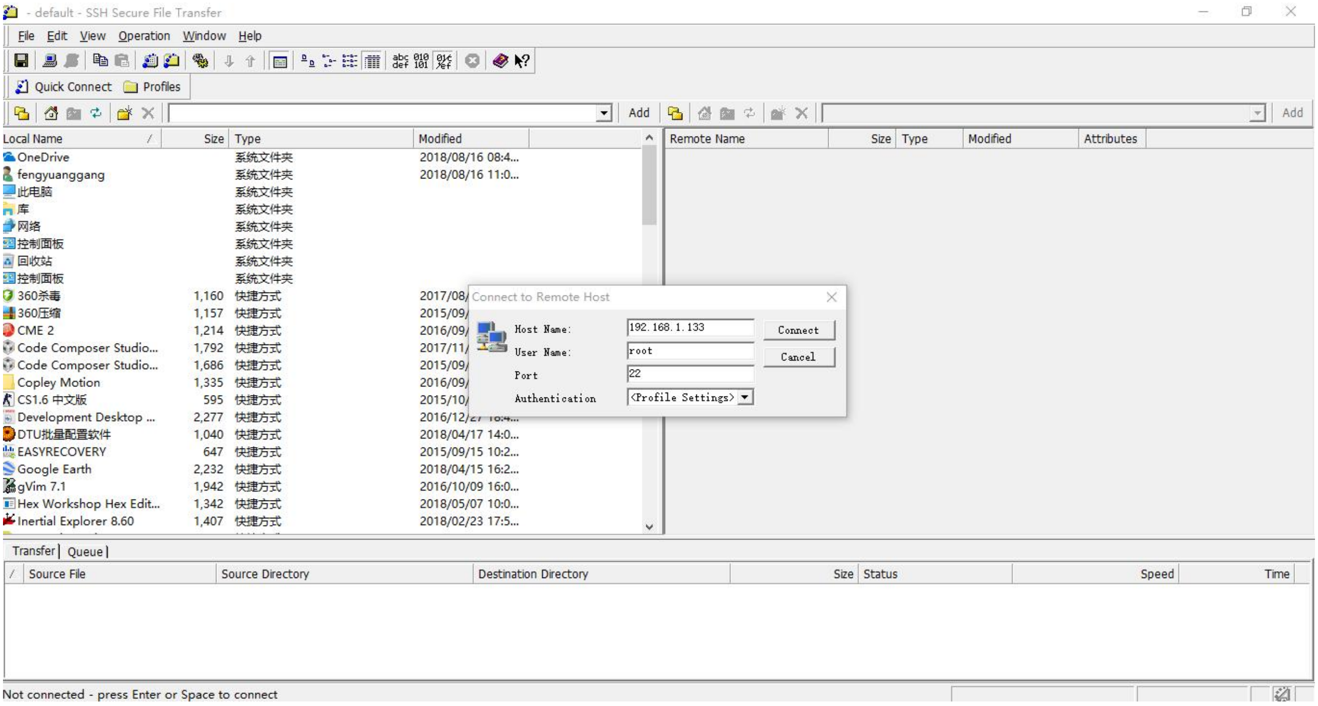

Figure 4 SSH Software Connection Diagram

f) Click Connect, and the SSH software will automatically pop up the "Enter Password" dialog box. There is no need to fill in the password. Click OK to connect to the system;

g) Enter/media/mmcblk0p1 in the address bar on the right side of the figure above and press Enter. Find the corresponding storage directory in the directory below to download.

h) When the download operation is complete, the system is powered off and the Ethernet interface is unplugged.

4.3.2 System configuration instructions

4.3.2.1 Configuration scheme and storage

The integrated navigation system provides 6-channel serial port and internal storage, and the function allocation and relevant configuration of each serial port and internal storage are shown in Table 3.

Table 3 Serial port function distribution of integrated navigation system

String slogans	Enter the item	Output items	Default
COM1	1. Working mode instruction and flow control instruction; 2. COM1 ~ COM4 baud rate, protocol and update rate configuration; 3.COM2 ~ COM4 serial port type configuration (RS422/RS232);	1.inspvasa、bdfpd 、bdfpdb、gpfpd、INStest(0.2Hz、1Hz、5Hz、10Hz、100Hz… 200 Hz, etc.); 2. rawdata (200Hz 16488 format); 3.rawimusb、INSpost（200Hz）; 4.bestposa、gprmc、gpgga（1Hz）; 5. Configure the prompt information.	115200bps; Output: bdfpd 1Hz;
COM2	None	Same as items 1-4 in COM 1	460800bps Output: INSpost
COM3	None	Same as items 1-4 in COM 1	460800bps Output: rawdata
COM4	None	Same as items 1-4 in COM 1	460800bps Output: None
File	None	Same as items 1-4 in COM 1	Output: rawdata
GNSS_COM1	GNSS COM1 Configuration Item	The NovAtel-718D supports protocols and configures outputs based on this interface, such as bestposa, gprmc, and so on	9600bps; Output: None
GNSS_COM3	GNSS COM3 Configuration Item	The NovAtel-718D supports protocols and configures outputs based on this interface, such as bestposa, gprmc, and so on	115200bps; Output: None

After the system is powered on and the start prompt information is displayed on the COM1 port, you can input commands such as COM1 ~ COM4 serial port baud rate configuration, serial port protocol and update rate setting. If each command is output successfully, it will return to the "cmd OK" ", otherwise it will display the" cmd error "". After the input is completed, type "saveconfig" to save the current configuration. The current configuration will be called automatically after the next restart. If the command is not input, the serial port configuration will be restored to the last saved configuration after the next restart.

4.3.2.2 Configuration Query

Type the "log loglist" or "log rxstatus" command through the COM1 port to list all the configurations of COM1-COM4, including the following contents:

a) Serial port number, serial port baud rate, serial port protocol and update rate;
b) Open state of function module: including zero-speed correction state and smooth processing state, enable when open and disable when closed;
c) Initial binding longitude and latitude;
d) Initially binding the included angle between the double-antenna heading and the integrated navigation system heading;
e) Initial binding antenna mast arm value;
f) System number and date of manufacture;
g) Software version number: including pre-processing software version number and navigation software version number;
h) Operating mode: including integrated navigation (DGI) and pure inertial navigation (INS).

4.3.2.3 Baud rate configuration

In this mode, enter the following command to enter the serial port baud rate configuration:

com comX BAUDRATA

Where X is from 1 to 4, and BAUDRATA is the baud rate in bps.

For example, set the baud rate of the COM1 port to the 115200 bps, and input the following command:

com com1 115200

4.3.2.4 Protocol and update rate configuration

4.3.2.4.1 Protocol and update rate configuration

Configure the output protocols of COM1 ~ COM4 and the internal storage file through COM1. The configuration commands are as follows:

log comX/file LOG ontime updataTime

Where comX can be the configuration number of com 1 to com 4, and file is the configuration number of the memory interface; The updataTime represents the update time, which can be a period of 5 (0.2Hz), 1 (1Hz), 0.2 (5Hz), 0.1 (10Hz) or 0.01 (100Hz) that can be divided by 200Hz, in s.

LOG indicates the protocol name, which can be inspvasa, bdfpd, gpfpd, etc.

For example, if you want to configure the COM2 port to output 10Hz bdfpd data, you can input the following command through COM1:

log com2 bdfpd ontime 0.1

If 10Hz inspvasa data needs to be output at COM2 at the same time, the following command can be input through COM1:

log com2 inspvasa ontime 0.1

As another example, to store inspvasa protocol data at 1 Hz to internal storage, enter the following command from COM1:

log file inspvasa ontime 1

If you want to shut down a protocol, the configuration command is as follows:

log comX/file LOG off

Configure the rawdata protocol of the COM1 ~ COM4 ports and the internal storage file through COM1. The configuration commands are as follows:

log comX/file rawdata onchanged

If you want to disable the rawdata protocol of the serial port, the configuration command is as follows:

log comX/file rawdata off

If you want to close all protocols of the serial port, the configuration command is as follows:

unlogall comX/file

It should be noted that increasing the update rate or outputting multiple protocols at the same time will increase the amount of data sent by the serial port. Before use, it is necessary to configure the appropriate baud rate, otherwise it may cause data loss. In general, the larger the amount of data, the higher the baud rate required.

4.3.2.4.2 Protocol format

The output protocols supported by the product are shown in the following table.

Table 4 Output Data Protocol Description

Serial number	Data protocol name	Type of agreement	Output type	Support interface
1	gpfpd	ASCII	ontime	COM1-COM4，file
2	bdfpd	ASCII	ontime	COM1-COM4，file
3	bdfpdb	Binary	ontime	COM1-COM4，file
4	rawimusb	Binary	onchanged	COM1-COM4，file
5	inspvasa	ASCII	ontime	COM1-COM4，file
6	INStest	Binary	ontime	COM1-COM4，file
7	bestposa	ASCII	onchanged	COM1-COM4，file
8	gprmc	ASCII	onchanged	COM1-COM4，file
9	gpgga	ASCII	onchanged	COM1-COM4，file
10	INSpost	Binary	onchanged	COM1-COM4，file
11	rawdata	Binary	onchanged	COM1-COM4，file

The ASCII type protocol conforms to the NMEA protocol format requirement and comprises the following fields: a statement identifier, a plurality of data fields,ChecksumEnd tag (with carriage return < CR > andLine break< LF >) separated by commas. Take the bdfpd protocol as an example, the format is as follows:

$BDFPD,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*xx<CR><LF>

The rawdata protocol includes rawimusb, rangecmpb, bestvelb, bestposb, headingb, and psrdopb. The contents of rangecmpb, bestvelb, bestposb, headingb and psrdopb protocols are shown in the NovAtel protocol description. The gprmc and gpgga protocols are in NMEA 0183 protocol data format, and bestposa is in NovAtel protocol data format, both of which forward the output of the satellite board and will not be introduced here. The protocol formats of gpfpd, bdfpd, inspvasa, bdfpdb, rawimusb and INStest are shown in the following table.

Table 5 gpfpd format

Serial number	Name	Meaning	Data type	Unit

Serial number	Name	Meaning	Data type	Unit
1	$GPFPD	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
7	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
8	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
9	Height	Height of the combined output	Floating-point type	m
10	East speed	Combined output east speed	Floating-point type	m/s
11	North speed	Combined output north speed	Floating-point type	m/s
12	Sky speed	Combined output speed	Floating-point type	m/s
13	Baseline length	Distance between centers of two satellite antenna	Integer	Meters
14	NSV1	Number of satellites for antenna 1	Integer	A
15	NSV2	Number of satellites for antenna 2	Integer	A
16	Satellite status	Satellite status 0: unavailable, 1: available	Integer	—
17	Check code	Check code (value after exclusive or of number between $and *)	Hexadecimal	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 6 bdfpd format

Serial number	Name	Meaning	Data type	Unit
1	$BDFPD	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s

Serial number	Name	Meaning	Data type	Unit
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
7	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
8	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
9	Height	Height of the combined output	Floating-point type	m
10	East speed	Combined output east speed	Floating-point type	m/s
11	North speed	Combined output north speed	Floating-point type	m/s
12	Sky speed	Combined output speed	Floating-point type	m/s
13	NSV1	Number of satellites for antenna 1	Integer	A
14	NSV2	Number of satellites for antenna 2	Integer	A
15	Positioning type	Pos type in bestpos, see Table 12	Integer	—
16	Directional type	Pos type in heading, see Table 12	Integer	—
17	Check code	Check code (value after exclusive or of number between $and *)	Hexadecimal	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 7 Format of inspvasa

Serial number	Name	Meaning	Data type	Unit
1	%INSPVASA	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
5	GPS cycles per second	GPS cycles per second	Floating point number	s
6	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree

Serial number	Name	Meaning	Data type	Unit
7	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
8	Height	Height of the combined output	Floating-point type	m
9	North speed	Combined output north speed	Floating-point type	m/s
10	East speed	Combined output east speed	Floating-point type	m/s
11	Sky speed	Combined output speed	Floating-point type	m/s
12	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
13	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
14	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
15	INS status	See Table 11	—	—
16	Check code	Check code (number between% and * 32-bit CRC check)	Hexadecimal	—
17	<CR><LF>	Fix the tail of the package	—	—

Table 8 bdfpdb protocol description

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0xaa	—	Header
	2		0x44	—	
	3		0x10	—	
2	4	Message length	0x3c	—	
3	5-8	Week of GNSS	Current Week Number Since 1980-1-6 (GMT)	unsigned int	—
4	9-12	Week second	GPS cycles per second	float	—
5	13-16	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	float	—
6	17-20	Pitch Angle	Pitch angle -90 ° ~ 90 °	float	—
7	21-24	Roll Angle	Roll angle -180 ° ~ 180 °	float	—
8	25-32	Latitude	Combined Output	double	—

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
			Latitude -90 ° ~ 90 °		
9	33-40	Longitude	Combined output longitude -180 ° ~ 180 °	double	—
10	41-44	Height	Height of the combined output	float	—
11	45-48	East speed	Combined output east speed	float	—
12	49-52	North speed	Combined output north speed	float	—
13	53-56	Sky speed	Combined output speed	float	—
14	57-58	NSV1	Number of satellites for antenna 1	unsigned short	—
15	59-60	NSV2	Number of satellites for antenna 2	unsigned short	—
16	61-62	Positioning type	Pos type in bestpos, see Table 12	unsigned short	—
17	63-64	Directional type	Pos type in heading, see Table 12	unsigned short	—
18	65-68	Checksum	5-64 bytes 4-byte accumulate sum check	—	—

Table 9 raw imusb protocol description

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0xaa	—	Header
	2		0x44	—	
	3		0x13	—	
2	4	Message length	0x28	—	
3	5-6	Message ID number	0x145	—	—
4	7-8	Week of GNSS	—	unsigned short	—
5	9-12	Week second	ms	unsigned int	—
6	13-16	Week of GNSS	—	unsigned int	
7	17-24	Week second	s	double	
8	25-28	IMU status word	See Table 13	unsigned int	
9	29-32	Z-direction accelerometer output (upper)	m/s^2	int	$200*200*2^{-31}$
10	33-36	-Y accelerometer	m/s^2	int	$200*200*2^{-31}$

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
		output (rear)			
11	37-40	X-direction accelerometer output (right)	m/s^2	int	$200*200*2^{-31}$
12	41-44	Z-direction gyroscope output (upper)	° /s	int	$200*720*2^{-31}$
13	45-48	-Y-gyro output (rear)	° /s	int	$200*720*2^{-31}$
14	49-52	X-direction gyroscope output (right)	° /s	int	$200*720*2^{-31}$
15	53-56	Checksum	1-52 byte 32-bit CRC check	unsigned int	—

Table 10 Description of INStest protocol

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0x5a	—	Header
	2		0x5a	—	
2	3	Data length	0x3c	unsigned char	—
3	4-7	Week second	s	float	—
4	8-9	Navigation Elevation	°	unsigned short	0.01
5	10-11	Pitch Angle	°	short	0.01
6	12-13	Roll Angle	°	short	0.01
7	14-15	North speed	m/s	short	0.01
8	16-17	East speed	m/s	short	0.01
9	18-19	Sky speed	m/s	short	0.01
10	20-23	Longitude	°	int	0.0000001
11	24-27	Latitude	°	int	0.0000001
12	28-29	Height	m	short	0.1
13	30-31	100 C serial number	—	unsigned short	—
14	32.0	Com1status	0: normal, 1: fault	—	—
15	32.1	Com2 status		—	—
16	32.2	Com3 status		—	—
17	32.3	GNSS com1status		—	—

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
18	32.4	Com4 status		—	—
19	32.5	GNSS com3 status		—	—
20	32.6	Status of the can interface		—	—
21	32.7	Odometer Interface Status		—	—
22	33.0	PPS status		—	—
23	33.1	EVENT status		—	—
24	34	INS status word	0 x00: Standby 0 x10: coarse alignment 0 x20: fine alignment 0 x30: Navigation	—	—
25	35	GNSS positioning type	Pos type in bestpos	—	—
26	36	Number of GNSS positioning satellites	—	—	—
27	37	Dual antenna directional type	Pos type in heading	—	—
28	38	Position the number of stars from the antenna	—	—	—
29	39-40	Gyro X axis	° /s	short	0.01
30	41-42	Gyro Y-axis	° /s	short	0.01
31	43-44	Gyro Z axis	° /s	short	0.01
32	45-46	Add Table X Axis	g	short	0.001
33	47-48	Add table Y axis	g	short	0.001
34	49-50	Add table Z axis	g	short	0.001
35	51	IMU fault word			
36	52-59	Spare	—	—	—
37	60-63	Frame count	0x0000~0xFFFF	unsigned int	—
38	64	Checksum	3-byte to 63-byte accumulate sum lower 8 bits	—	—

Table 11 INS Status Description

INS status word	Status word description
INS_INACTIVE	IMU logs are present, but the alignment routine has not started; INS is inactive.

INS_ALIGNING	INS is in alignment mode.
INS_SOLUTION_GOOD	The INS filter is in navigation mode and the INS solution is good.

Table 12 pos type description

Type numeric value	Type definition	Type description
0	NONE	No solution
1	FIXEDPOS	Position has been fixed by the FIX POSITION command
2	FIXEDHEIGHT	Position has been fixed by the FIX HEIGHT/AUTO command
8	DOPPLER_VELOCITY	Velocity computed using instantaneous Doppler
16	SINGLE	Single point position
17	PSRDIFF	Pseudorange differential solution
18	WAAS	Solution calculated using corrections from an WAAS
19	PROPAGATED	Propagated by a Kalman filter without new observations
20	OMNISTAR	OmniSTAR VBS position
32	L1_FLOAT	Floating L1 ambiguity solution
33	IONOFREE_FLOAT	Floating ionospheric-free ambiguity solution
34	NARROW_FLOAT	Floating narrow-lane ambiguity solution
48	L1_INT	Integer L1 ambiguity solution
50	NARROW_INT	Integer narrow-lane ambiguity solution
64	OMNISTAR_HP	OmniSTAR HP position
65	OMNISTAR_XP	OmniSTAR XP or G2 position
68	PPP_CONVERGING	Converging PPP solution
69	PPP	Converged PPP solution
70	OPERATIONAL	Solution accuracy is within UAL operational limit
71	WARNING	Solution accuracy is outside UAL operational limit but within warning limit
72	OUT_OF_BOUNDS	Solution accuracy is outside UAL limits

Table 13 IMU Status Word Description

Bit sequence number	Type description	
0	X Gyro status	1: normal, 0: fault
1	Y Gyro status	
2	Z gyro status	
3	Spare	
4	X Accelerometer Status	1: normal, 0: fault
5	Y Accelerometer Status	
6	Z Accelerometer Status	
7-31	Spare	—

4.3.2.4.3 32-bit CRC check calculation method

The 32-bit CRC check calculation method can be obtained by using the following C language function.

```
#define CRC32_POLYNOMIAL 0xEDB88320L
/* ----------------------------------------------------------------------------
Calculate a CRC value to be used by CRC calculation functions.
-------------------------------------------------------------------------- */
unsigned long CRC32Value(int i) {
     int j;
     unsigned long ulCRC;
     ulCRC = i;
     for ( j = 8 ; j > 0; j-- ) {
          if ( ulCRC & 1 )
               ulCRC = ( ulCRC >> 1 ) ^ CRC32_POLYNOMIAL;
          else
               ulCRC >>= 1;
     }
     return ulCRC;
}

/* ----------------------------------------------------------------------------
Calculates the CRC-32 of a block of data all at once
ulCount - Number of bytes in the data block
ucBuffer - Data block
-------------------------------------------------------------------------- */
unsigned long CalculateBlockCRC32( unsigned long ulCount, unsigned char
*ucBuffer ) {
     unsigned long ulTemp1;
     unsigned long ulTemp2;
     unsigned long ulCRC = 0;
     while ( ulCount-- != 0 ) {
          ulTemp1 = ( ulCRC >> 8 ) & 0x00FFFFFFL;
          ulTemp2 = CRC32Value( ((int) ulCRC ^ *ucBuffer++ ) & 0xFF );
          ulCRC = ulTemp1 ^ ulTemp2;
     }
     return( ulCRC );
}
```

4.3.2.5 Initial value configuration

Initial longitude and latitude configuration, configuration instructions are:

initialpos LONGITUDE LATILUDE

Where LONGITUDE and LATITUDE are configured local longitude and latitude values in degrees.

4.3.2.6 Function module configuration

Functional modules with open configuration mainly include zero velocity correction and output position smoothing.

4.3.2.6.1 "Zero speed correction" configuration

The zero-velocity correction function mainly means that the integrated navigation system detects the sensitive information, and if the integrated navigation system is judged to be zero-velocity, the corresponding correction is carried out.

In the integrated navigation process of this product, the "zero velocity correction" is enabled by default. If the satellite information is invalid for a long time in the integrated navigation state, and the user wants to get the pure inertial navigation information, it is recommended to close the zero velocity correction mode.

The zero speed correction configuration instructions are as follows:

inszupt switch

The switch value is either disable or enable, where disable turns the feature off and enable turns the feature on.

4.3.2.6.2 Position Output Smoothing Configuration

In order to get more smooth position information, the navigation software adds the function of position output smoothing, which makes the position noise smaller after smoothing. (Note: "Position output smoothing" shall be closed in RTK state)

In the integrated navigation process of this product, "Position Output Smoothing" is off by default. In order to facilitate the user's selection, this function can be configured. The configuration instructions are as follows:

possmooth switch

The switch value is either disable or enable, where disable turns the feature off and enable turns the feature on.

4.3.2.7 Carrier type configuration

According to different carriers installed in the integrated navigation system, the carrier type configuration is required, and different algorithm processing is carried out in the integrated navigation system according to different carrier types.

The configuration instructions are as follows:

carrier vehicle/ship/air

They are vehicle-mounted, ship-mounted and airborne in turn.

After the configuration is completed, you need to enter the save command "saveconfig", and then hard start or enter the "# reset" command. The carrier type configuration will be valid after startup. The integrated navigation system does not support current configuration and current use during use, and must be restarted.

After the carrier type is configured as the vehicle-mounted type, the integrated navigation system is required to be installed and fixed on the vehicle, and the heading of the integrated navigation system is consistent with the head direction of the vehicle, with an error of not more than 10 degrees.

4.3.2.8 GNSS mast arm configuration

According to the relative installation relationship between the antenna and the integrated navigation system, it is necessary to configure the antenna rod arm. The lever arm value between the integrated navigation system and the antenna must be accurate to millimeter (mm) during measurement, especially during RTK operation. Any lever arm measurement error will directly enter the position error output by the integrated navigation system. During installation and use, the integrated navigation systems shall be as close as possible to the main antenna, especially in the horizontal position. The command is required to be completed before or during the alignment of the integrated navigation system on the stationary base and before the alignment of the integrated navigation system on the moving base. Once the configuration is complete, it needs to be saved via "saveconfig".

The configurations include a master antenna rod arm configuration and a slave antenna rod arm configuration.

The main antenna configuration instructions are as follows:

setimutoantoffset armX armY armZ

The slave antenna configuration instructions are as follows:

setimutoantoffset2 armX armY armZ

Where armX, armY, and armZ are configured lever arm values, in meters, representing the components of the vector from the integrated navigation system to the antenna phase center in the integrated navigation system carrier coordinate system, which is selected as right front up (XYZ). For the example in Figure 5, armX and armY should be negative, and armZ should be positive.

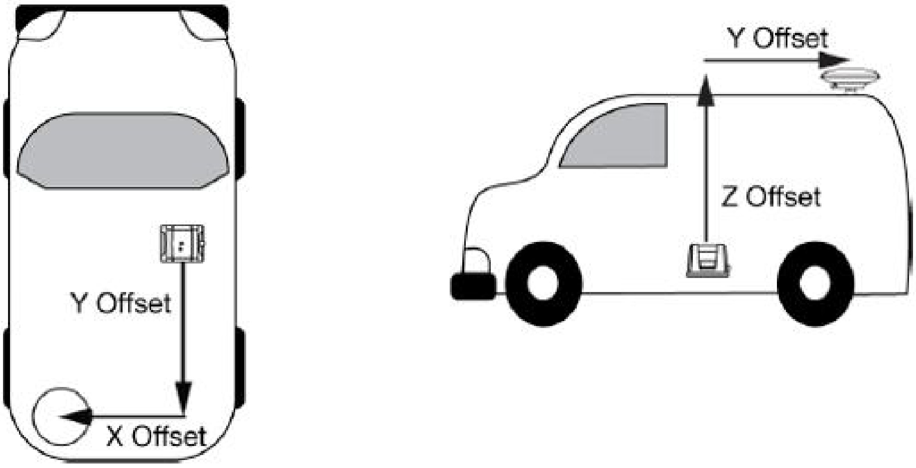

Figure 5 Schematic diagram of antenna rod arm

4.3.2.9 Output lever arm setting

The default value for the product output lever arm configuration is [0,0,0] (upper right front), which outputs the position and speed values at the integrated navigation system. If the position and speed of the user's test point need to be output, the output lever arm should be set according to the relative installation relationship between the test point and the integrated navigation system.

The lever arm value from the configuration of integrated navigation system to the test point must be accurate to millimeters (mm) during measurement, especially during RTK operation, any lever arm measurement error will directly enter the position error output by the integrated navigation system. The command is required to be completed before or during the alignment of the integrated navigation system on the stationary base and before the alignment of the integrated navigation system on the moving base. Once the configuration is complete, it needs to be saved via "saveconfig".

The output lever arm configuration instructions are as follows:

setimutosensoroffset armX armY armZ

Where armX, armY, and armZ are configured lever arm values, in meters, representing the components of the vector from the integrated navigation system to the test point in the integrated navigation system carrier coordinate system, which is selected as right front up (XYZ). For the example in Figure 6, armY and armZ should be positive.

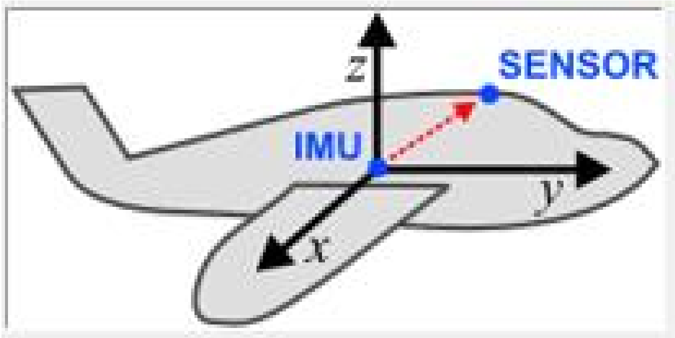

Fig. 6 Schematic diagram of output lever arm

4.3.2.9 Setting of installation angle

The attitude and heading information output by the product are Euler angles of the product coordinate system relative to the geographic coordinate system. The angle installation relationship between the product and the carrier coordinate system is the installation angle, and the default configuration value is [0,0,0] (pitch, heading, roll), that is, the product coordinate system is considered to coincide with the installation carrier coordinate system. If there is an installation angle when the product is installed on the carrier, and the Euler angle of the carrier coordinate system relative to the geographic coordinate system needs to be output by the product, the installation angle should be set according to the relative installation relationship between the product and the carrier.

The mounting angle configuration instructions are as follows:

vehiclebodyrotation angleX angleZ angleY

Where angleX, angleZ and angleY are the configured installation angle values, in degrees, representing the angles from the carrier coordinate system to the integrated navigation system coordinate system, in the order of pitch, course and roll.

4.3.2.10 Output angle setting

The attitude and heading information output by the product are Euler angles of the product coordinate system relative to the geographic coordinate system. The angular relationship between the product and the specified coordinate system is the output angle, and the default configuration value is [0,0,0] (heading, pitch, roll), that is, the product coordinate system is considered to coincide with the specified coordinate system. If the Euler angle of the specified coordinate system relative to the geographic coordinate system needs to be output, the output angle should be set according to the relative relationship between the product and the specified coordinate system.

The output angle configuration instructions are as follows:

outputattituderotation angleZ angleX angleY

Where angleZ, angleX, and angleY are the configured output angle values, in degrees, representing the angle from the specified coordinate system to the product coordinate system, in the order of heading, pitch, and roll.

Note: This function cannot be used in conjunction with the mounting angle setting.

4.3.2.11 Forced-turn inertial navigation

When the integrated navigation system is in the integrated navigation state, it can receive the forced inertial navigation command and turn to the inertial navigation state. In this state, the integrated navigation system still receives the satellite navigation information for protocol transmission, but does not use the satellite navigation information to participate in the integrated guidance calculation. After receiving the effective forced rotation inertial navigation command, the integrated navigation system feeds back the "cmd OK" "through the COM1 port.

Forced-turn inertial navigation commands are as follows:

#moddgitoins

4.3.3 System maintenance

4.3.3.1 Firmware upgrade

When a firmware upgrade is required, proceed as follows:

a) Connect the power line and communication line, connect the COM1 port to the computer, and set the baud rate to 115200 bps;

b) When the system is powered on, the serial port tool interface displays startup prompt information. Before the interface displays "10 9 8 7 6 5 4 3 2 1" to 1, send ":" (small colon, cancel the option of sending a new line) to the serial port, and the interface displays updata flash information;

c) Select the firmware (generally *.bin2 file) to be upgraded through the serial port tool and send it;

d) After the sending is completed, the program automatically reloads and starts, enters the start prompt information, and starts normally;

e) The firmware upgrade is complete.

4.3.3.2 Parameter upload

In general, the user does not need to upload the calibration parameters, and the configuration has been completed before leaving the factory. Under special circumstances, if the user is required to upload and maintain the parameters, the following steps shall be followed:

a) After the system completes the startup prompt information normally, you can query the corresponding system number through the "log bdlist"/ "log rxstatus";
b) Send the "# modbd" command to the integrated navigation system through the COM1 port, and upload the "*.txt" calibration parameter file through the serial port after returning to the "cmd OK" ";
c) After the interface returns to the calibration parameter information, send the "# saveconfig"/ "saveconfig" command to save the parameters, and then reset the system to work normally.

5. Precautions

The main considerations are as follows:

a) The power-on and power-off time interval of the integrated navigation system shall not be less than 30 s, otherwise it is easy to cause damage to the inertial devices;
b) Handle with care during handling, installation and use to avoid bumping, falling and bumping;
c) Do not change the output and baud rate configuration of the COM2 port of the satellite board.

6. Appendix

6.1 COM2 output configuration of satellite receiver

The integrated navigation system receives satellite navigation information through the COM2 port of the built-in satellite receiver. The COM2 port configuration command of the satellite receiver is as follows:

unlogall com2

serialconfig com2 115200

log com2 gprmc ontime 1

log com2 gpgga ontime 1

log com2 bestposa ontime 1

Log com2 rangecmpb ontime 1 (Note: this command is invalid without the original data board)

log com2 bestposb ontime 0.2

log com2 headingb onchanged

log com2 bestvelb ontime 0.2

log com2 psrdopb ontime 1

dualantennaalign enable 5 1

frequencyout enablesync 100000 1000000000

saveconfig

6.2 Description of differential configuration

The integrated navigation system can receive the differential correction information sent by the reference station through the communication link, work in the differential state, and achieve the positioning accuracy of centimeter level. Differential configuration mainly includes three parts: 1. Reference station setting; 2. Communication link setting; 3. Mobile station setting. The data link is shown in the following illustration.

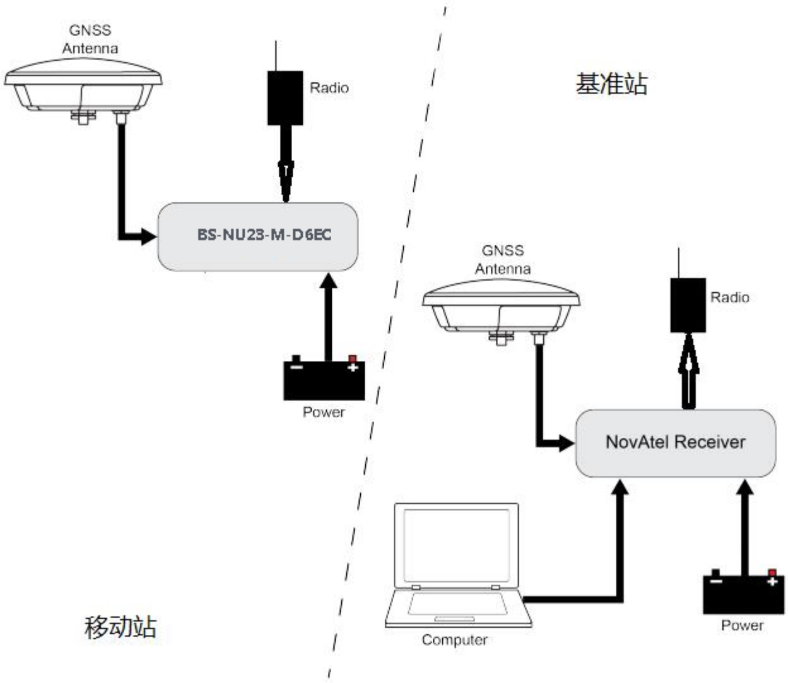

Figure 7 Data Link Diagram

6.2.1 Setting of reference station

The differential reference station is the satellite receiver with the satellite receiver antenna installed in a fixed position. During the use of the satellite receiver, it is necessary to ensure that the antenna position is fixed. In the working process of the differential reference station, the precise coordinates of the fixed position and the received satellite information are sent to the mobile station (the point to be positioned) through the communication link, which is used for the mobile station to carry out differential positioning calculation, realize differential high-precision positioning, and achieve centimeter-level positioning accuracy.

The NovAtel-718D satellite receiver card can be applied to the reference station, and it can be configured as the reference station mode. The specific configuration instructions are as follows. See the NovAtel-718D user manual for details.

Table 14 Reference Station Configuration Instructions

Serial number	Instruction	Explain
1	fix position 39.8122 116.1515 60.5	Set the known precise coordinates (latitude 39.8122, longitude 116.1515, altitude 60.5) as the reference station coordinate values
	posave on 0.01 1.5 2.5	Autonomous positioning of the receiver: 0.01h; Or when the horizontal positioning standard deviation is less than or equal to 1.5m and the height positioning standard deviation is less than or equal to 2.5m, the average value of the positioning is taken as the coordinate value of the reference station
2	serialconfig com1 9600	Set the output baud rate of the output interface COM1 of the reference station to 9600 bps
3	interfacemode com1 novatel rtcmv3 on	Configure COM1 input data type as novatel, output data type as rtcmv3, and enable command feedback
4	log com1 rtcm1075 ontime 1	GPS differential message
5	log com1 rtcm1125 ontime 1	BDS differential message
6	log com1 rtcm1085 ontime 1	GLO differential message
7	log com1 rtcm1033 ontime 10	Description of receiver and antenna
8	log com1 rtcm1005 ontime 10	Antenna reference point coordinates of RTK reference station
9	saveconfig	Save the configuration

6.2.2 Communication Link Settings

The communication link can use 4G DTU or data radio, and the coverage of 4G DTU is the coverage of network information; Limited by the national laws, the coverage of the digital radio station is about 10km. For the setting of 4G DTU and digital radio, please refer to the user manual of the corresponding product.

6.2.3 Mobile Station Settings

The integrated navigation system is a differential mobile station. The mobile station receives the differential correction information of the reference station in real time, and at the same time receives the satellite signal for differential positioning solution to achieve differential high-precision positioning. The integrated navigation system supports RTCM and RTCMV3 standard data protocols. GNSS _ COM1 or GNSS _ COM3 of the integrated navigation system can be configured as the receiving interface of differential correction information. The specific configuration instructions are as follows. See the NovAtel-718D user manual for details.

Table 15 Mobile station configuration command

Serial number	Instruction	Explain
1	serialconfig com1 9600	Set the input baud rate of the mobile station input interface COM1 to 9600 bps
2	interfacemode com1 rtcmv3 novatel on	Configure COM1 output data type as novatel, input data type as rtcmv3, and enable command feedback
3	saveconfig	Save the configuration