V 1.12 of optical fiber integrated navigation system.

BS-FN300D-M-D6EC

Product characteristics

- Gyroscope measuring range: 500 ~ 2000 °/s optional
- 2 °/H gyroscope bias stability (Allan variance)
- Acceleration range: 16g
- Zero bias stability (Allan variance) for acceleration of 0.1 mg

Field of application

UAVNavigation

Vehicle & Robot Navigation

AUV &ROV

1. Product overview

The fiber-optic integrated navigation system BS-FN300D-M-D6EC is based on the closed-loop fiber-optic gyroscope, accelerometer and high-end GNSS receiving board with high cost performance, and is realized through multi-sensor fusion and navigation calculation algorithm to meet the requirements for accurate measurement of attitude, heading, position and other information in the application fields of medium and high precision mobile measurement systems and large unmanned aerial vehicles.

2. Functions and indicators

2.1 Main functions

The system has inertial/satellite integrated navigation mode and pure inertial mode.

In the inertial/satellite integrated navigation mode, the satellite positioning information received by the GNSS receiver can be used for integrated navigation, and the pitch, roll, course, position, speed, time and other information of the carrier can be output; After the signal is lost, the position, velocity and attitude calculated by inertia are output, in which the pitch and roll are required to be accurate, the course keeping function is available in a short time, and the meter-level positioning accuracy is available in a short time. In the integrated navigation mode, the post-processing information can be output for processing by the IE post-processing software of NovAtel.

After the pure inertial mode (that is, GNSS fusion has never been performed after power-on, and if it loses lock again after fusion, it belongs to the integrated navigation mode) is started, it has the function of accurate attitude measurement, can output the pitch and roll course, and the pure inertial mode can find the north statically.

2.2 Performance indicators

Parameter		Technical indicators
Position accuracy	Single point (RMS)	1.2m
	RTK（RMS）	2cm+1ppm
	Post-processing (RMS)	1cm+1ppm
	Lock-loss accuracy (CEP)	2 nm, out of lock for 60 min ①
Heading (RMS)	Real-time combination accuracy	0.1°②
	Post-processing	0.003°
	Lock-loss holding accuracy	0.02 °, out of lock for 60 min ①
	Self-north seeking	0.1 ° SecL, alignment for 15 min ③

Parameter		Technical indicators
	accuracy	
Attitude (RMS)	Combined accuracy	0.01°
	Post-processing	0.002°
	Lock-loss holding accuracy	0.02 °, out of lock for 60 min ①
Horizontal Velocity Accuracy (RMS)	0.05m/s	
Timing accuracy	20ns	
Data output frequency	200Hz④	
Gyroscope	Range	300°/s
	Zero bias stability	0.02°/h⑤
	Scale factor Nonlinearity	50ppm
	Angular random walk	0.005°/√hr
Accelerometer	Range	16g
	Zero bias stability	50ug⑤
	Scale factor Nonlinearity	50ppm
	Speed random walk	0.01m/s/√hr
Physical dimensions and electrical characteristics	Overall dimensions	176.8mm×188.8mm×117mm
	Weight	< 5kg (without cable)
	Input voltage	12～36VDC
	Power consumption	< 24W (steady state)
	Store	Reserved
Environmental indicators	Operating temperature	-40°C~+60°C
	Storage temperature	-45℃～+70℃
	Random vibration	6.06g，20Hz˜2000Hz
	MTBF	30000h
Interface characteristics	PPS、EVENT、RS232、RS422、CAN	
	Network port	
	Antenna interface	
	Wheel speed sensor interface	
Note 1: ① Alignment is valid; ② Onboard condition, maneuver is required; ③ Dual-position alignment, the heading difference between two positions is greater than 90		

Parameter	Technical indicators
degrees; ④ Single-channel output is 200Hz; ⑤ 10s average. Note 2: Post-processing indicators:	

Table 1 System Performance Requirements

GNSS Unlock duration	Positioning mode	Location/meter (RMS)		Velocity/m/s (RMS)		Attitude/° (RMS)		
		Level	Elevation	Level	Tianxiang	Roll	Pitch	Heading
0s	RTK	0.02	0.03	0.008	0.008	0.010	0.010	0.030
	SP	1.00	0.60	0.008	0.008	0.010	0.010	0.030
	PP	0.01	0.02	0.008	0.008	0.002	0.002	0.003
10s	RTK	0.20	0.20	0.020	0.020	0.011	0.011	0.031
	SP	1.10	0.80	0.020	0.020	0.011	0.011	0.031
	PP	0.01	0.02	0.008	0.008	0.002	0.002	0.003
60s	RTK	1.20	1.00	0.050	0.050	0.012	0.012	0.033
	SP	1.80	1.50	0.050	0.050	0.012	0.012	0.033
	PP	0.030	0.020	0.008	0.008	0.002	0.002	0.003
600s	RTK	25.00	20.00	0.150	0.100	0.015	0.015	0.035
	SP	50.0	45.0	0.200	0.180	0.015	0.015	0.035
	PP	2.000	1.800	0.300	0.200	0.005	0.005	0.008

3. How it works

3.1 Product composition

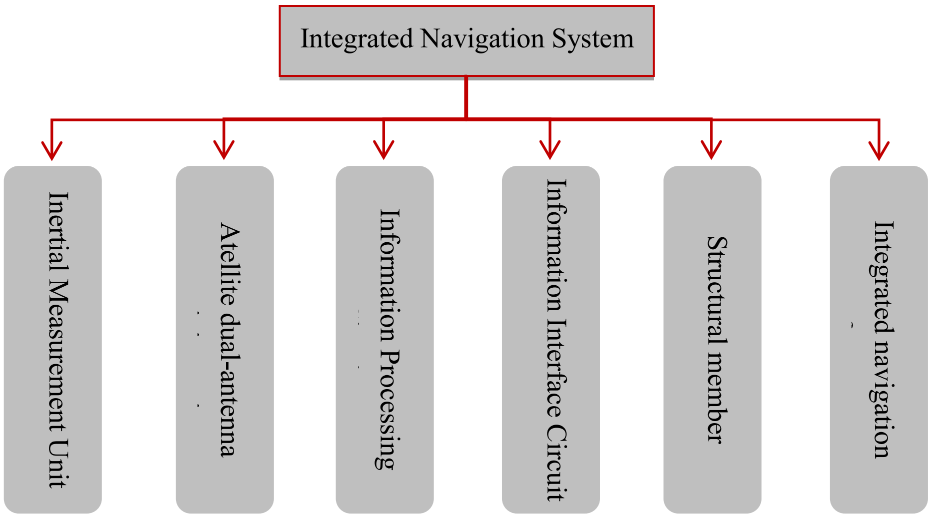


Figure 1 System composition

3.2. Rationale

The inertial measurement unit consists of three accelerometers and three optical fiber 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 satellite 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 unit.

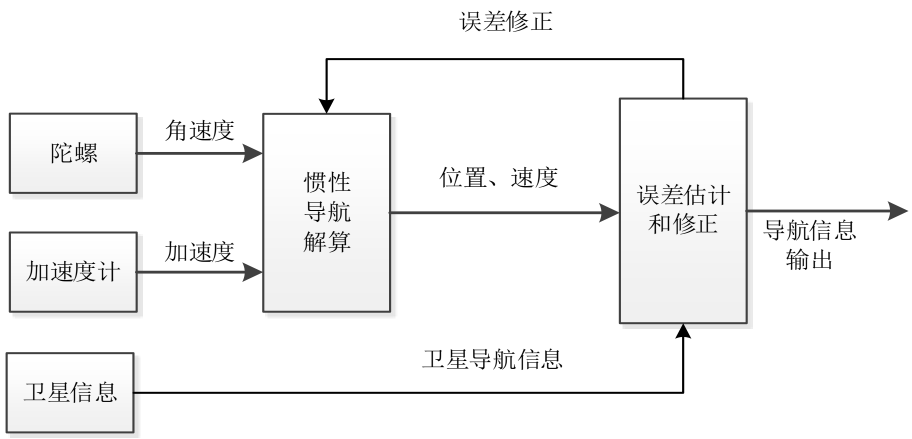


Fig. 2 Schematic diagram of working principle

4. Instructions for use

4.1 Overall dimensions

The inertial measurement unit and the satellite receiver are integrated in the inertial navigation system. The outline of the system is shown in the figure below. The overall dimension of the system is: 176.8 mm × 188.8mm × 117mm (length × width × height).

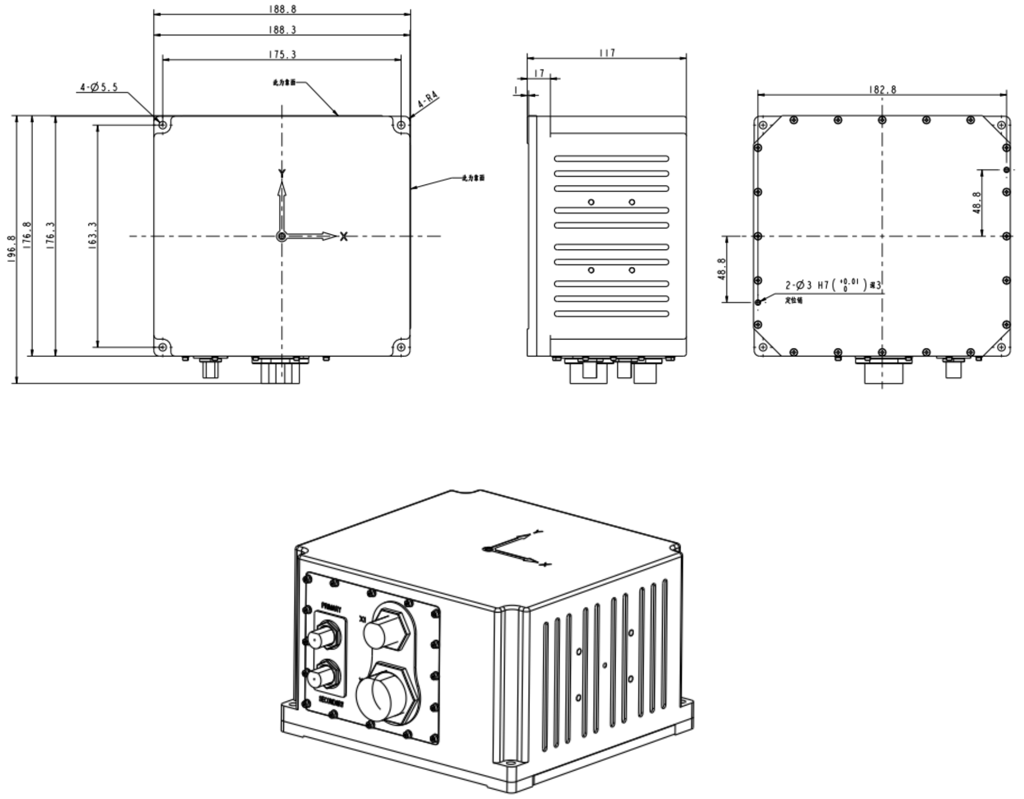


Fig. 3 Structure Diagram of Overall Dimensions

4.2 Electrical interface

The system has four external connectors:

A) an X1 power supply interface and X2 communication interface

B) two RF line interfaces (TNC outer screw and inner hole, where the upper is connected to the master antenna and the lower is connected to the slave antenna)

One end of one power cable of the c) is connected with X1, and the other end is connected with 13 ~ 36 V DC;

One end of d) 1 communication cable is connected to X2, and the other end is divided into 5 serial ports, which are COM2 ~ COM5, wherein COM5 is RS232, COM2, COM3 and COM4 are RS232, and RS422 can be configured. COM2 can be used to send the working mode command, and COM5 can be configured with the GNSS board inside the inertial navigation system;

External connector points are defined as shown in Table 1 and Table 2:

X1(J599/26FA35SA)	Signal definition	Plug wire code	Remark

1	DC+	Red alligator clip, Large size	Power supply positive
2	DC+		
3	DC+		
4	DC-	Black alligator clip, Large size	Power supply negative
5	DC-		
6	DC-		

Table 2 X1 Connector Point Definitions

X2(J59 9/26FD 35PA)	Signal definition	Plug wire code	Terminal number	Remark
1	COM2_TXD_RS232	COM 1 (DB 9 female)	1-DB 9 holes: 2	Main processor program upgrade port, RS232
2	COM2_RXD_RS232		1-DB 9 holes: 3	
3	GND		1-DB 9 holes: 5	
4	COMA_422T_ N/RS232_T	COM2 (DB 9 female)	2-DB 9 holes: 2	First configurable serial port RS422/RS232 Default RS 232
5	COMA_422T_P		2-DB 9 holes: 6	
6	COMA_422R_N		2-DB 9 holes: 8	
7	COMA_422R_P/ RS232_R		2-DB 9 holes: 3	
8	GND		2-DB 9 holes: 5	
9	COMB_422T_ N/RS232_T	COM3 (DB 9 female)	3-DB 9 holes: 4	The second channel can be configured with serial port RS422/RS232 RS422 is the default
10	COMB_422T_P		3-DB 9 holes: 3	
11	COMB_422R_N		3-DB 9 holes: 2	
12	COMB_422R_ P/RS232_R		3-DB 9 holes: 1	
13	GND		3-DB 9 holes: 5	
14	COMC_422T_ N/RS232_T	COM4 (DB 9 female)	4-DB 9 holes: 4	The third channel can be configured with serial port RS422/RS232
15	COMC_422T_P		4-DB 9 holes: 3	
16	COMC_422R_N		4-DB 9 holes: 2	

17	COMC_422R_ P/RS232_R		4-DB 9 holes: 1	RS422 is the default
18	GND		4-DB 9 holes: 5	
19	RS232-718-TXD1	COM5 (DB 9 female)	5-DB 9 holes: 2	718D serial port 1
20	RS232-718-RXD1		5-DB 9 holes: 3	
21	GND		5-DB 9 holes: 5	
22	PPS	No plug, wire throwing	PPS	3.3V TTL
23	EVENT2	No plug, wire throwing	EVENT2	3.3V TTL
24	CAN1_P	No plug, wire throwing	CAN1_P	CAN
25	CAN1_N	No plug, wire throwing	CAN1_N	
26	DI1+	No plug, wire throwing	DI1+	First route odometer (5V-12V)
27	DI1-	No plug, wire throwing	DI1-	
28	DI2+	No plug, wire throwing	DI2+	The second way odometer (5V-12V)
29	DI2-	No plug, wire throwing	DI2-	
30	GND	No plug, wire throwing	GND	
31	ETHER _ TX _ P (3 green-white)	Network port (RJ45)	1 (orange white)	10/100 Ethernet interface
32	ETHER _ TX _ N (6 green)		2 (orange)	
33	ETHER _ RX _ P (1 orange-white)		3 (green and white)	
34	ETHER _ RX _ N (2 orange)		6 (green)	
35	CAN2_P	No plug, wire	CAN2_P	CAN

		throwing		
36	CAN2_N	No plug, wire throwing	CAN2_N	
37	-	-	-	-

Table 3 X2 Connector Point Definitions

4.3 Instructions for use

4.3.1 workflow

Inertial navigation system includes two work processes, one is integrated navigation process, the other is pure inertial navigation process.

4.3.1.1startup prompt message

Connect the cable, power up the system, and monitor the COM2 interface information through the serial port debugging tool of the test computer. After the interface displays "Please enter NaviMode within 20s!", the serial port debugging tool can be used to send workflow instructions to the COM2 interface. "# moddgi" is the working instruction for entering the integrated navigation; if no instruction is sent within 20 s, the system will automatically enter the internally saved workflow after 20 s.

4.3.1.2 integrated navigation proces

After entering the integrated navigation process, first bind the satellite information. If the satellite is not positioned, it is in the state of waiting for the satellite information. When the satellite information is valid, it enters the alignment state. The alignment time is 1 minute. During the alignment period, the inertial navigation is required to be static. After the alignment is completed, the inertial navigation can move and the system is in the integrated navigation state.

4.3.1.3 pure inertial navigation proces

After entering the pure inertial navigation process, first carry out rough alignment for 1min. If the satellite information is valid, bind the satellite information and carry out fine alignment for 1500s. If there is no satellite information, the stationary base must be aligned for 1500s. After the alignment is completed, turn to the pure inertial navigation state, and the inertial navigation can move.

4.3.2 system configuration instruction

4.3.2.1 Configuration Scheme and Storage

The inertial navigation system provides 4 external serial ports (configuration No.: com2 ~ com5) and one internal storage channel (configuration No.: file). The function allocation and relevant configuration of each serial port are shown in the following table.

Configuration numbe	**Enter the project**	**Output items**	**Default**

r			
COM2	1. working mode instruction and flow control instruction; 2.COM2 ~ COM4 baud rate configuration; 3.COM2 ~ COM4 protocol and update rate configuration; 4.Store the file port protocol configuration.	1.SNCNAVPVTB (0.2 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz, etc.); 2.GPFPD (0.2 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz, etc.); 3.BDFPD (0.2 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz, etc.); 4.INSPVASA (0.2 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz, etc.); 5. INSPBASB (0.2 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz, etc.); 6.RAWIMUSB (fixed 200Hz SPAN-ISA-100C format); 7.RAWDATA (fix RAWIMUSB in 200Hz SPAN-ISA-100C format and include the data sent by satellite card COM2); 8. configure prompt information;	RS232； 460800bps； Output: INSPVASA 1Hz；
COM3	None	Same as COM2	RS422； 460800bps； Output: None
COM4	None	1.Same as COM2 2.It can be configured to directly connect to the COM3 port of the 718 D card.	RS422； 460800bps； Output: None
COM5	OEM 718D COM1 configuration items;	Configure the output according to this interface, such as BESTPOSA, GPRMC, and so on	RS232; 9600bps; Output: none
file	The system automatically saves the storage information according to the user's configuration. The name of the saved data file is RECORDX. Txt, where X is the file number. When a configuration query is	1. There will be a fixed SNCPOST protocol and it cannot be cancelled. The protocol is data backup. 2. When the system is powered on, the network port is inserted into the computer to	None

	made, the current latest file name is displayed.	store and export data.	

Table 4 Function Distribution of Serial Port of Inertial Navigation System

After the system is powered on and the start information is displayed on the COM2 port, you can input the commands such as COM2 ~ COM5 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 COM2 port to list all configurations of COM2 ~ 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; carrier type;

c. Internal storage status information: including the file name of the last file, remaining space, etc.;

d. Initial binding longitude and latitude;

e. System number and date of manufacture;

f. Software version number: including pre-processing software version number and navigation software version number;

g. Operating mode: including integrated navigation (DGI) and pure inertial navigation (INS).

4.3.2.3 baud rate setting

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

com comX BAUDRATA

Where X is 2 ~ 4 and BAUDRATA is the baud rate in bps.

For example, set the baud rate of the COM2 port to 460800 bps, and input the following command:

com com2 460800

4.3.2.4 Serial Port RS232 Configuration

When the serial port is configured as RS232 (if the serial port is configured as COM3-COM4, an adapter cable is required. See Section 4.2 Electrical Interface for the definition of the cable), the command is as follows:

rs232 COMX

Where X is 2 ~ 4.

For example, set the COM3 port as RS232, and input the following commands:

rs232 com3

4.3.2.5 serial port RS422 configuration

When the serial port is configured as RS422 (if the serial port is configured as COM2, an adapter cable is required. See Section 4.2 Electrical Interface for the definition of the cable), the command is as follows:

rs422 COMX

Where X is 2 ~ 4.

For example, set the COM2 port as RS422, and input the following commands:

rs422 com2

4.3.2.6 update rate configuration

Configure the protocols of COM2 ~ COM5 and GPFPD, BDFPD, inspvasa and inspvasb of the memory file port through COM2. The configuration commands are as follows:

log comX/file LOG ontime updataTime

Where comX can be the configuration number of com2 to com4, file is the configuration number of the memory interface; updataTime represents the update time, which can be 5 (2 Hz), 1 (1 Hz), 0.2 (5 Hz), 0.1 (10 Hz), 0.01 (20 Hz) and other periods that can be divided by 200 Hz, and the unit is s. LOG represents the protocol name, which can be inspvasa, inspvasb, gpfpd, bdfpd.

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

log com2 gpfpd ontime 0.1

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

log com2 bdfpd ontime 0.1

As another example, to store 1 Hz inspvasa protocol data in the ins internal memory, enter the following command via COM2:

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 rawimusb and rawdata protocols of the COM2 ~ COM4 ports and the memory file port through COM2. The configuration commands are as follows:

log comX/file rawdata onchange

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 several 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.

Longitude and latitude configuration of 4.3.2.7 initial values

Initial longitude and latitude configuration, the configuration command is:

initialpos LONGITUDE LATILUDE

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

4.3.2.8 function module configuration

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

4.3.2.8.1 "Zero Velocity Trim" Configuration

The zero-speed correction function mainly means that the inertial navigation system detects the sensitive information, and if the inertial navigation system is judged to be zero-speed, 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.

4.3.2.8.2 Position Output Smoothing configuration

The position information in the INSPVASA and GPFPD protocols is the inertial navigation position information. In order to obtain more smooth position information, the position output smoothing function is added to the navigation software, and the position noise after smoothing is smaller.

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 values are disable and enable, where disable means to turn off the function and enable means to turn on the function.

4.3.2.9 satellite serial port mapping configuration

If the satellite board has no extra serial port to configure or use during use, the satellite board serial port can be mapped to the external interface COM4, and two commands are configured as follows:

connect gpscard com2

connect gpscard com3

connect gpscard disable

Sending the connect gpscard com2 command will map the COM2 of the satellite board card 718D to the external connection port COM4. At this time, the COM4 port must be configured as a 230400 before the configuration of the satellite navigation card board can be performed. This command will cause the inertial navigation to work in an abnormal state. After the board is configured, the inertial navigation needs to be restarted before the inertial navigation can be in the normal state, and the command will not be saved after the command is restarted.

Send the connect gpscard com3 command to map the COM3 of the satellite card 718D to the external interface COM4. At this time, the baud rate of the COM4 interface must be configured to be the baud rate of the COM3 of the 718D to perform normal communication. If it needs to be saved, send the saveconfig command.

Send the connect gpscard disable command to restore the external COM4 serial port to the internal CPU output port.

4.3.2.10 carrier type configuration

According to the different carriers installed in the inertial navigation system, the carrier type configuration is required, and different algorithm processing is carried out in the 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 save config, and then hard start or enter the # reset command. The carrier type configuration will be valid after startup. The inertial navigation system does not support the current configuration and current use, and must be restarted.

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

4.3.2.11 online RTK

When online RTK processing is used, com2 input commands are required as follows:

possmooth disable

Configuration of com1 port of com5 (7180D): Figure 4 Schematic diagram of antenna rod arm

Serialconfig com1 9600 (variable baud rate, depending on actual DTU configuration)

interfacemode com1 rtcmv3 novatel on

saveconfig

4.3.2.12 GNSS antenna mast arm configuration

According to the relative installation relationship between the antenna and the inertial navigation system, it is necessary to configure the antenna rod arm. The lever arm value between the configuration inertial navigation and the antenna must be accurate to millimeters (mm) during measurement. Any measurement error of the lever arm will directly enter the position error output by the inertial navigation. During installation and use, the inertial navigation should be as close as possible to the main antenna, especially in the horizontal position. The command is required to be completed before the alignment of the inertial navigation static base or during the alignment of the inertial navigation static base and before the alignment of the dynamic 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:

setimutoantoffset1 armX armY armZ

The slave antenna configuration instructions are as follows:

setimutoantoffset2 armX armY armZ

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

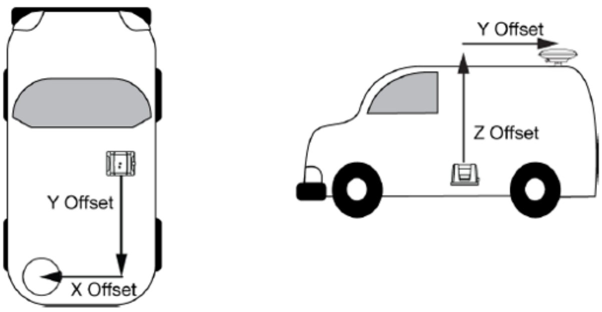


Figure 4 Schematic diagram of antenna rod arm

4.3.2.13 Output Lever Arm Settings

The default value for the product output lever arm configuration is [0,0,0] (upper right front), which is the position and velocity values at the output ins. If the position and speed of the user 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 inertial navigation.

The lever arm value between the configuration inertial navigation and the test point must be accurate to millimeters (mm) during measurement, and any lever arm measurement error will directly enter the position error output by the inertial navigation. The command is required to be completed before the alignment of the inertial navigation static base or during the alignment of the inertial navigation static base and before the alignment of the dynamic base. Once the configuration is complete, it needs to be saved via "saveconfig".

The output lever arm configuration commands are as follows:

setimutosensoroffset armX armY armZ

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

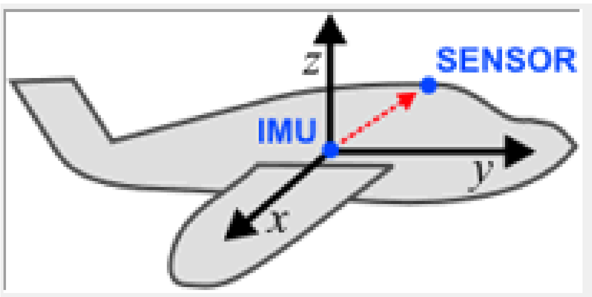


Fig. 5 Schematic diagram of output lever arm

Setting of mounting angle of 4.3.2.14

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.

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.

Note: This function will cause the output angular velocity, acceleration and attitude to change with the setting.

4.3.3 protocol format

4.3.3.1 SNCNAVPVTB

Examples of inertial navigation configuration commands:

log com2 sncnavpvtb ontime 1

Byte sequence number	Data	Data type	Number of bytes occupied	Explain
0	0x55	unsigned char	1	Fixed 0x55
1	0xAA	unsigned char	1	Fix 0 xAA
2	Class	unsigned char	1	Fix 0 x00
3	ID	unsigned char	1	Fix 0 x00
4-5	Frame length	unsigned short	2	
6-7	Frame count	unsigned short	2	Adds 1 for each frame sent
8-9	Week (GPS hour)	unsigned short	2	Week No. In Unit
10-17	Cycles per second (GPS hours)	double	8	In S
18-21	Heading	int	4	Units are in degrees LSB=0.0001°
22-25	Pitch	int	4	Units are in degrees LSB=0.0001°
26-29	Roll	int	4	Units are in degrees LSB=0.0001°

30-33	East speed	int	4	Units are in degrees LSB=0.0001 m/s
34-37	North speed	int	4	Units are in degrees LSB=0.0001 m/s
38-41	Sky speed	int	4	Units are in degrees LSB=0.0001 m/s
42-45	Latitude	int	4	Units are in degrees LSB=0.0000001°
46-49	Longitude	int	4	Units are in degrees LSB=0.0000001°
50-53	Height	int	4	The unit is meter LSB=0.0001m
54-57	X-axis angular velocity (Right-front-up)	int	4	Units are in degrees LSB=0.000001°/s
58-61	Y-axis angular velocity (Right-front-up)	int	4	Units are degrees/second LSB=0.000001°/s
62-65	Z-axis angular velocity (Right-front-up)	int	4	Units are degrees/second LSB=0.000001°/s
66-69	X-axis acceleration (Right-front-up)	int	4	In m/S2 LSB=0.0000001 m/s2
70-73	Y-axis acceleration (Right-front-up)	int	4	In m/S2 LSB=0.0000001 m/s2
74-77	Z-axis acceleration (Right-front-up)	int	4	In m/S2 LSB=0.0000001 m/s2
78	Number of main antenna	unsigned char	1	The unit is piece LSB＝1

	positioning star			
79	Position the number of stars from the antenna	unsigned char	1	The unit is piece LSB＝1
80	Navigation status word	unsigned char	1	Bit7-Bit0 0 x00: Standby 0 x10: coarse alignment 0 x20: fine alignment 0x30: integrated navigation 0x31: pure inertial navigation
81-82	GNSS status word	unsigned short	2	Bit2-Bit0 = 0: Invalid = 1: single point positioning = 2: pseudorange differential = 3: RTK differential positioning Bit 3: Position and speed data are valid = 0: Invalid = 1: Valid Bit 4: GNSS dual-antenna heading is valid = 0: Invalid = 1: Valid Bit5: GPS data is valid = 0: Invalid = 1: Valid Bit 6-Bit 15: Reserved as 0
83-84	Fault status word	unsigned short	2	Bit 0: X-axis gyro fault word = 0: normal = 1: Fault Bit 1: Y-axis gyro fault word = 0: normal = 1: Fault Bit2: Z-axis gyro fault word = 0: normal = 1: Fault

				Bit3: X-axis acceleration fault word = 0: normal = 1: Fault Bit 4: Y-axis acceleration fault word = 0: normal = 1: Fault Bit5: Z-axis acceleration fault word = 0: normal = 1: Fault Bit 6: GNSS board hardware fault word = 0: normal = 1: Fault Bit 7-Bit 15: Reserved as 0
85-92	Reserved	-	8	-
93-94	Checksum	-	2	Accumulate 2-92 to lower 16 bits

Table 5 sncnavpvtb format

4.3.3.2 GPFPD

Examples of inertial navigation configuration commands:

log com2 gpfpd ontime 1

Ins output example

$GPFPD,2083,199022.049,271.356,-2.149,0.767,39.7085178,116.1311212,39.93,-11.422,-0.077,0.050,1.500,27,0,1*59

Serial	Name	Meaning	Data	Unit
1	$GPFPD	Format header	—	—
2	GPSWeek	Current week number (GMT) since January 6, 1980	Integer	—
3	GPS cycles	GPS cycles per second	Floating	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-	Degre
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-	Degre
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-	Degre

7	Latitude	Inertial navigation output latitude -90 ° ~ 90 °	Floating-	Degre
8	Longitude	Inertial navigation output longitude -180 ° ~ 180 °	Floating-	Degre
9	Height	Height of inertial navigation output	Floating-	m
10	East speed	Inertial navigation output east speed	Floating-	m/s
11	North speed	Inertial navigation output north speed	Floating-	m/s
12	Sky speed	Inertial navigation outputs sky speed	Floating-	m/s
13	Baseline	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	Satellite status 0: unavailable, 1: available	Integer	—
17	Check code	Check code	Hexadeci	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 6 Format of GPFPD

4.3.3.3 BDFPD

Examples of inertial navigation configuration commands:

log com2 gpfpd ontime 1

Ins output example

$BDFPD,2105,355160.246,90.96184,-1.14427,1.01899,39.71066564,116.11209956,46.076,-0.0037,-0.0065,0.0147,20,16,0*68

Seria	Name	Meaning	Data type	Unit
1	$BDFPD	Format header	—	—
2	GPSWeek	Current week number (GMT) since January 6, 1980	Integer	—
3	GPS cycles	GPS cycles per second	Floating point	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point	Degr
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point	Degr
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point	Degr
7	Latitude	Inertial navigation output latitude -90 ° ~ 90 °	Floating-point	Degr
8	Longitude	Inertial navigation output longitude -180 ° ~ 180 °	Floating-point	Degr
9	Height	Height of inertial navigation output	Floating-point	m
10	East speed	Inertial navigation output east speed	Floating-point	m/s
11	North speed	Inertial navigation output north speed	Floating-point	m/s

Seria	Name	Meaning	Data type	Unit
12	Sky speed	Inertial navigation outputs sky speed	Floating-point	m/s
13	NSV1	Number of satellites for antenna 1	Integer	A
14	NSV2	Number of satellites for antenna 2	Integer	A
15	Positioning	Pos type in bestpos	Integer	—
16	Directional	Pos type in heading	Integer	—
17	Check code	Check code	Hexadecimal	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 7 BDFPD format

4.3.3.4 short message protocol head

There are two types of short header protocol headers, one is ASCII and the other is binary.

Serial	Name	Data type	Meaning
1	%	Char	Fixed to '%'
2	Message name	Char	Message type for this protocol
3	GPS Week	Ushort	GPS weeks (GPS hours)
4	GPS cycles per	float	GPS Week Second (GPS Hour)

Table 8 ASCII Short Header

Seri	Name	Data type	Meaning	Binary	Binar
1	Sync Byte	Char	Fix Hex 0xAA	1	0
2	Sync Byte	Char	Fix Hex 0x44	1	1
3	Sync Byte	Char	Fix Hex 0x13	1	2
4	Message	Uchar	Message length, excluding header and	2	3
5	Message ID	Ushort	Message ID	2	4
6	GPS Week	Ushort	GPS weeks (GPS hours)	4	6
7	GPS cycles	Int	GPS cycle second (GPS hour,	4	8

Table 9 Binary short header

4.3.3.5 32-bit CRC check

The C language code history is as follows.

```
#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 );
```

}

4.3.3.6 INSPVAS

This command is a short message protocol output

Examples of inertial navigation configuration commands:

log com2 inspvasa ontime 1 (ASCII)

Log com2 inspvasb ontime 1 (binary)

ASCII example

%INSPVASA,1264,144059.000;

1264,144059.002135700,51.116680071,-114.037929194,515.286704183,277.896368884,84.915188605,-8.488207941,0.759619515,

-2.892414901,6.179554750,INS_ALIGNMENT_COMPLETE*855d6f76

Serial	Name	Meaning	Data Type	Binary Byte	Binary Offse
1	INSPVAS Header	Message header	—	H	0
2	Week	GPS weeks (GPS hours)	Ulong	4	H
3	Seconds	GPS Week Second (GPS Hour)	Double	8	H+4
4	Latitude	Latitude (WGS84) [degrees]	Double	8	H+12
5	Longitude	Longitude (WGS84) [degrees]	Double	8	H+20
6	Height	Height above mean sea level [metres]	Double	8	H+28
7	North Velocity	North direction velocity (negative value	Double	8	H+36
8	East Velocity	East velocity (negative value indicates	Double	8	H+44
9	Up Velocity	Celestial velocity [m/s]	Double	8	H+52
10	Roll	Scroll [degrees]	Double	8	H+60
11	Pitch	Pitch [degrees]	Double	8	H+68
12	Azimuth	Heading angle (0-360) [degrees]	Double	8	H+76
13	Status	Inertial navigation status word	Enum	4	H+84
14	xxxx	32-bit CRC	Hex	4	H+88
15	[CR][LF]	Fixed end (ASCII only)	-		—

Table 10 INSPVAS format

Binary	ASCII	Meaning

Binary	ASCII	Meaning
0	INS_INACTIVE	Inertial navigation
1	INS_ALIGNING	Ins alignment status
3	INS_SOLUTION_GOOD	Inertial navigation
6	INS_SOLUTION_FREE	Inertial navigation pure

Table 11 Inertial Navigation Status

4.3.3.7 RAWIMUS

This command is a short message protocol output (binary output only).

Examples of inertial navigation configuration commands:

Raw imusb onchanged of log com2 (binary)

Serial number	Name	Meaning	Data type	Binary Byte	Binary Offse
1	RAWIMUS Header	Message header	—	H	0
2	Week	GPS weeks (GPS hours)	Ulong	4	H
3	Seconds	GPS Week Second (GPS Hour)	Double	8	H+4
4	IMU Status	IMU status word	Hex Ulong	4	H+12
5	Z Accel Output	Fixed 200 Hz, divided by 250000.0. Becomes Z acceleration m/S2 (right-front-up)	Long	4	H+16
6	- (Y Accel Output)	Fixed 200 Hz, divided by-250000.0. Becomes Y acceleration m/S2 (right-front-up)	Long	4	H+20
7	X Accel Output	Fixed 200 Hz, divided by 250000.0. Becomes X acceleration m/S2 (right-front-up)	Long	4	H+24
8	Z Gyro Output	Fixed 200 Hz, divided by 5000000.0. Becomes Z angular velocity rad/s (right-front-up)	Long	4	H+28
9	- (Y Gyro Output)	Fixed 200 Hz, divided by-5000000.0.	Long	4	H+32

Serial number	Name	Meaning	Data type	Binary Byte	Binary Offse
		Becomes Y angular velocity rad/s (right-front-up)			
10	X Gyro Output	Fixed 200 Hz, divided by 5000000.0. Becomes X angular velocity rad/s (right-front-up)	Long	4	H+36
11	xxxx	32-bit CRC	Hex	4	H+40
12	[CR][LF]	Fixed end (ASCII only)	-		—

Table 12 RAW IMUS format

IMU type	Peg-top	Acceleration
ISA-100C	1.0E-9 rad/LSB	2.0E-9 m/s/LSB

Table 13 Raw IMU Scale

4.3.3.8 RAWDATA

Wherein the protocol is a protocol set, It includes the RAWIMUSB (200HZ) protocol of IMU raw data in the inertial navigation system and the BESTPOSB (1HZ), BESTVELB (1HZ), PSRDOPB (1HZ), HEADINGB (1HZ), RANGECMPB (Satellite Navigation Raw Data Option) protocol.

Examples of inertial navigation configuration commands:

log com2 rawdataonchanged

4.3.4 data export

This product has the function of data storage, with a total storage space of 16g (the internal system recovery partition and files used by other systems will be included, so it will be less than the normal empty SD card). 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 will be automatically overwritten in the next storage, and X will still increase 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. In addition, the current latest file name will also be displayed during configuration query.

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:

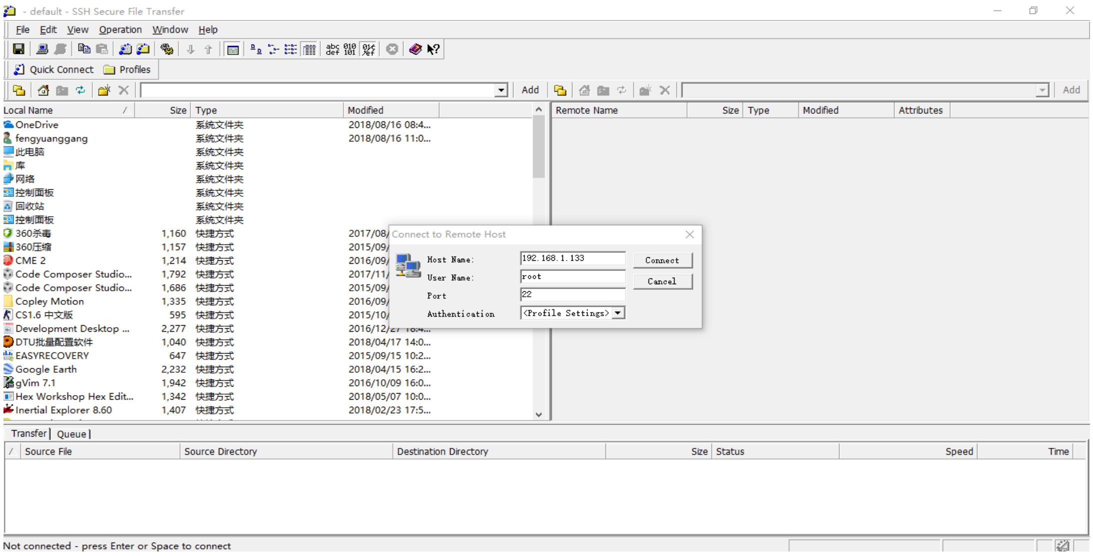
The a) connects the Ethernet interface with the test computer;

The b) sets the IP address of the test computer as a 192.168.1.22;

The c) system is powered on;

The d) runs SSH software (SSH Secure File Transfer Client);

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



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

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

When the h) download operation is complete, power down the system and unplug the Ethernet connector.

4.3.5 system maintenance

4.3.5.1 firmware upgrade

The operation steps are as follows:

1) connecte an inertial navigation COM1 and a network port to a computer, and set an IP port of that network port of the computer as a 192.168.1.22;

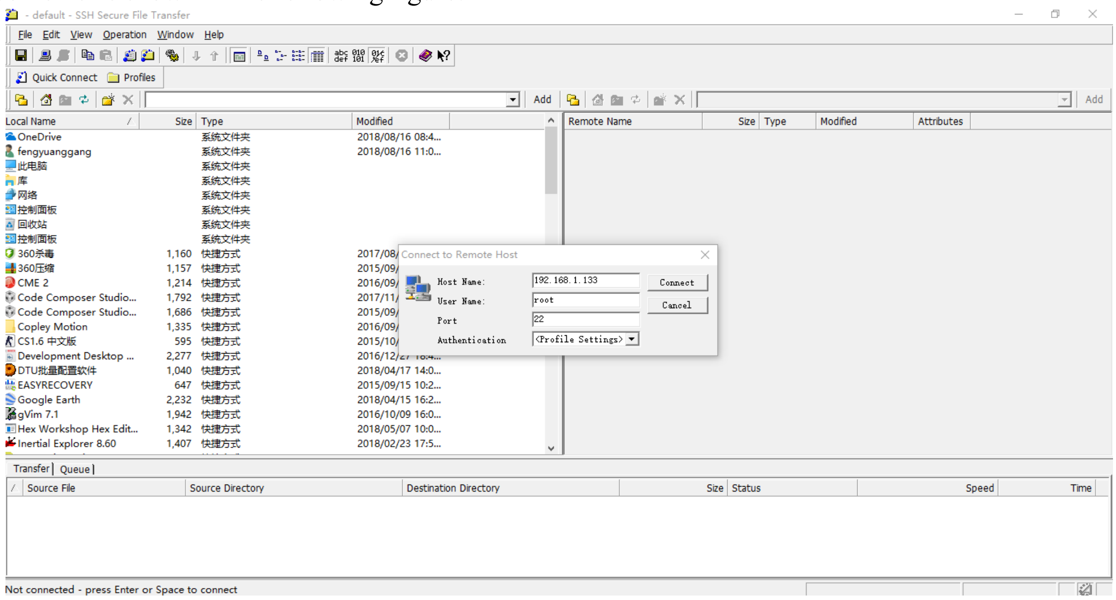
2) open that CRT of the upper computer software, open the corresponding serial port, and setting the serial port as a baud rate 115200, an 8-bit data bit, a 1-bit stop bit and a non-parity bit;

3) energize that integrated navigation system;

4) Observe the CRT display, wait for the Linux boot to complete, enter the command $GPEXT, and

the command line will appear.

5) Run the SSH software (SSH Secure File Transfer Client), click Quick Connect, and fill in the contents as shown in the following figure:



6) 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;

7) Enter/home/root/install in the address bar on the right side of the above figure and press Enter to delete the files ins 300_ dgi (Linux application), ins 300_ dgi _ DSP. Out (DSP program) and ins300imu.bin (FPGA program). Copy the new ins 300_ dgi, ins 300_ dgi _ DSP. Out, and ins300imu.bin file. Select the three files and right click Properties to change the permission to 777, and then enter the sync command in COM1 to synchronize the files.

8) If the FPGA program needs to be upgraded, it is necessary to send the/home/root/update _ FPGA. Sh from COM1, and wait for the COM1 prompt that the upgrade is successful.

9) The upgrade is completed when the product is restarted.

5. Precautions

The main considerations are as follows:

1) The power-on and power-off time interval of the inertial navigation system shall not be less than 30 s, otherwise the inertial device may be damaged;

2) Handle with care during handling, installation and use to avoid collision, falling and impact;

3) After the inertial navigation system is started, it is necessary to wait for the inertial navigation system to complete the coarse alignment before it can move linearly. The coarse alignment time is about 1 minute, otherwise the measurement accuracy will be affected;

4) After the carrier type is configured as the vehicle-mounted type, the inertial navigation system shall be installed and fixed on the vehicle, and the heading of the inertial navigation system shall be

consistent with the head direction of the vehicle, with an error of not more than 10 degrees.

6. Appendix

Output Configuration of Satellite Receiver COM2 and COM3 of 6.1 Integrated Navigation System

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

unlogall com2

serialconfig com2 460800

log com2 headingb onchanged

DUALANTENNAALIGN enable 5 5

log com2 psrdopb ontime 1

log com2 bestposb ontime 0.2

log com2 bestvelb ontime 0.2

log com2 timeb ontime 1

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

frequencyout enablesync 100000 1000000000

saveconfig

If you want to use the COM3 of the satellite board, you can refer to the 4.3.2.9 section, but you need to configure the following command to change the multiplex pin of the satellite board into the serial port COM3.

INTERFACEMODE USB1 NONE NONE

INTERFACEMODE USB2 NONE NONE

INTERFACEMODE USB3 NONE NONE

MARKCONTROL MARK1 DISABLE

INTERFACEMODE COM3 NOVATEL NOVATEL

115200 of serialconfig com3 (Note: Baud rate can be set as the desired baud rate, but the baud rate of inertial navigation COM4 port shall be more consistent)

saveconfig

Use of post-processing of the 6.2

The integrated navigation system can use Inertial Explorer commercial software for post-processing, and the NovAtel-718D receiver card of the integrated navigation system is required to carry raw data, in which the rawdata protocol and base station data of the integrated navigation system are required to be recorded. NovAtel-718D satellite receiver card can be applied to the reference station (it is required to be able to output the original observed quantity). The recommended configuration of the receiver is shown in the following table, and the detailed description is shown in the NovAtel-718D user manual.

Serial	Instruction	Explain
1	serialconfig com2 230400	Configure com2 baud rate as 230400 (230400 is recommended here, and 230400 baud rate is
2	fix position 39.8122 116.1515 60.5	Set the known precise coordinates (latitude 39.8122，经度 116.1515，altitude 60.5) as the
3	log com2 bestposb ontime 1	Configure com2 output satellite positioning
4	log com2 ionutcb onchanged	Configure com2 to output the ionospheric model
5	log com2 rawephemb onchanged	Configure com2 to output GPS ephemeris
6	log com2 gloephemerisb onchanged	Configure com2 to output GLONASS
7	log com2 bdsephemerisb onchanged	Configure com2 to output BD ephemeris
8	log com2 qzssephemerisb onchanged	Configure com2 to output QZSS ephemeris
9	log com2 rangeb ontime 1	Configure com2 to output the original observation quantity (pseudorange, carrier
10	log com2 versionb ontime 600	Configure com2 to output board information

Table 14 Reference Station Configuration Instructions

Description of 6.3 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.

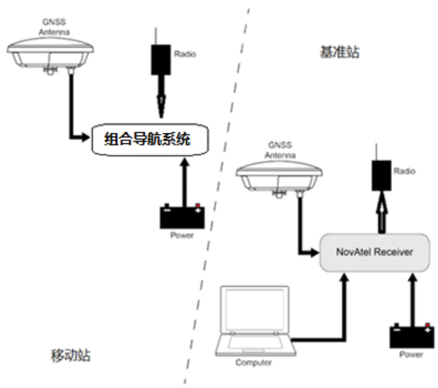


Figure 7 Data Link Diagram

Setting of 6.3.1 reference station

The differential reference station is the satellite receiver with the antenna of the satellite receiver installed in a fixed position. During the use of the satellite receiver, the antenna position shall be 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 reference station can be configured in the reference station mode by using the GNSS satellite receiver board. The specific configuration instructions are as follows, and the detailed description is shown in the GNSS user manual.

Serial	Instruction	Explain
1	fix position 39.8122 116.1515 60.5	Set the known precise coordinates (latitude 39.8122，经度 116.1515，altitude 60.5）as the
	posave on 0.01 1.5 2.5	When the receiver autonomously positions 0.01 H, or the standard deviation of horizontal positioning is less than or equal to 1.5m, and the
2	serialconfig com1 9600	Set the output baud rate of the output interface COM1 of the reference station to 9600 bps
3	interfacemode com1 none rtcmv3 off	Configure COM1 input data type as novatel, output data type as rtcmv3, and enable
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
9	saveconfig	Save the configuration

6.3.2 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; subject to national laws, the coverage of data radio is about 10 km. For the setting of 4G DTU and digital radio, please refer to the user manual of the corresponding product.

6.3.3 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 receives the satellite signal to calculate the differential positioning, so as to realize the 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.

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 none off	Configure COM1 output data type as novatel, input data type as rtcmv3, and enable command feedback
3	saveconfig	Save the configuration

Table 15 Mobile station configuration command

7. Update the record

Serial number	Version	Change the date	Before the change	After the change	Reason for the change	Changed by
1	V1.00	20200826			The 1、is newly compiled	Zzy
2	V1.01	20200826			2、 Modify Lever Arm Value Command	Zzy
3	V1.02	20200903			1、 adding electrical interface multiplexing RS232 and RS422 2、Add configuration RS 232 and 3、RS422 command	Zzy
4	V1.03	20200910			Add RAWIMUSB 1、 Configure the output command	Zzy
5	V1.04	20201009			1、add INSPVAS, RAWIMUS protocol format	Zzy
6	V1.05	20201015			1、Modify INSPVAS Wait for the agreement to be expressed in Chinese	Zzy

7	V1.06	20201022			Add firmware upgrade instruction Add Appendix Satellite Receiver Configuration	Zzy
8	V1.07	20201109			Added Appendix Satellite COM2 Receiver Configuration timeb and COM3 Receiver Configuration	Zzy
9	V1.08	20201114			Modified rawimusb protocol accelerometer unit	Zzy
10	V1.09	20201120			Add SNCNAVPVTB protocol 1、.	Zzy
11	V1.10	20210105			1、Modify the satellite card COM2 configuration	Zzy
12	V1.11	20210108			Add installation dimension and location of locating hole in the structure diagram Modify SNCNAVPVTB protocol	Zzy
13	V1.12	20220322			Optimized post-processing and online lock-loss accuracy Amend some of the statements Optimized random vibration index	Zzy