V 1.01 of optical fiber integrated navigation system.

BS-FN500-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 hicle & Robot Navigation / &ROV

1. Product overview

BS-FN500-M-D6EC fiber-optic integrated navigation system (hereinafter referred to as "inertial navigation") is based on high-precision closed-loop fiber-optic gyroscope, accelerometer and high-end GNSS receiving board. It is realized through multi-sensor fusion and navigation algorithm, providing high-precision attitude, speed and position information to meet the requirements of high-precision measurement and control.

2. Main functions and indicators

2.1 Main functions

The system has inertial/satellite integrated navigation mode and pure inertial mode. The inertial navigation system has a built-in GNSS board. When the GNSS is valid, the inertial navigation system can perform integrated navigation with the GNSS, and provide the user with navigation parameters such as the combined position, altitude, speed, attitude, course, acceleration, and angular velocity, and output information such as the GNSS position, altitude, and speed. When the GNSS is invalid, it can enter the pure inertial mode (that is, GPS fusion has never been carried out after power-on, and if it loses lock again after fusion, it belongs to the integrated navigation mode). After starting, it has accurate attitude measurement function, can output the pitch and roll course, and the pure inertia can find the north statically.

Key features include:

Initial alignment function of a): After the inertial navigation system is powered on, wait for the satellite information to be valid. After the satellite is valid, carry out alignment for 600 seconds. After the alignment is completed, turn to the inertial navigation system in the integrated navigation state;

B) integrated navigation function: after the initial alignment, it is immediately switched to the integrated navigation state, and the inertial navigation uses the internal GNSS board to carry out the integrated navigation, which can calculate the navigation information such as the speed, position and attitude of the carrier;

C) communication function: Inertial navigation can output inertial navigation measurement information according to the protocol;

The d) has the ability to upgrade the software in situ on the aircraft: the navigation software can be upgraded through the serial port;

The e) has the ability of self-test. When the system fails, it can send invalid and alarm information to the relevant equipment;

The f) has a wobble alignment function.

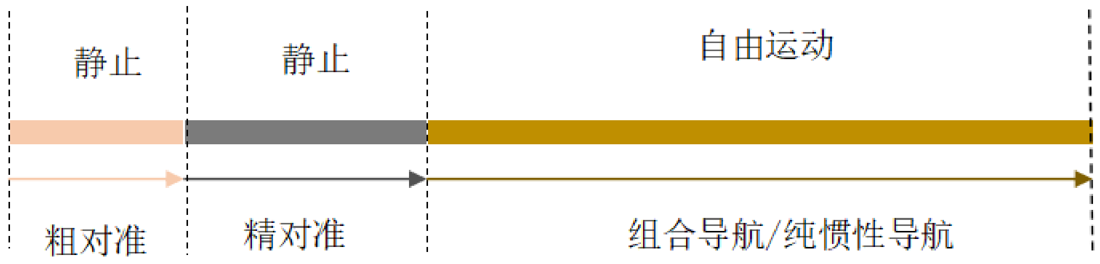


Fig. 1 Inertial Navigation Work Flow Chart

2.2 Main technical indicators

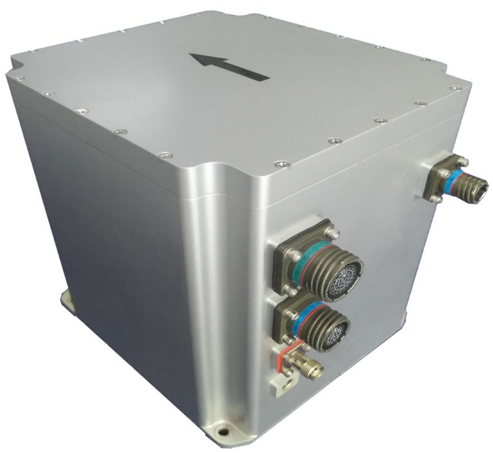
Project	Test conditions	Indicators
Positioning accuracy	GNSS Valid, Single Point	1.2m（RMS）
	GNSS Valid, RTK	2cm+1ppm（RMS）
	Position hold (GNSS failure)	0.8nm/h（CEP）， 3.0nm/3h（CEP）
Heading accuracy	Self-seeking north	0.06 ° × sec (Lati), 5min alignment of stationary base; 0.03 ° × sec (Lati), 10 min alignment of stationary base; Where Lati denotes the latitude (RMS).
	Course keeping (GNSS failure)	0.02°/h（RMS）， 0.05°/3h（RMS）
Attitude accuracy	GNSS is valid	0.01°（RMS）
	Attitude hold (GNSS failure)	0.01°/h（RMS）， 0.03°/3h（RMS）
Speed accuracy	GNSS valid, single point L1/L2	0.1m/s（RMS）
	Speed hold (GNSS failure)	0.8m/s/h（RMS）， 3m/s/3h（RMS）
Optical fiber Gyroscope	Measuring range	±400°/s
	Zero bias stability	≤0.01°/h
Quartz flexibility Accelerometer	Measuring range	±20g
	Zero bias stability	≤ 20 μg (10 s average)
Communication interface	RS422	6-channel, baud rate 9.6 kbps ~ 921.6 kbps, 默认 115.2 kbps Maximum frequency 1000Hz, default 200Hz

	RS232	Channel 1, baud rate 9.6 kbps ~ 921.6 kbps, 默认 115.2 kbps Maximum frequency 1000Hz, default 200Hz
	CAN	Two ways
	Ethernet	One way, RJ45 external plug
Electrical characteristics	Voltage	24～36VDC
	Power consumption	≤30W
Structural characteristics	Size	199 mm × 180 mm × 219.5 mm (L × W × H)
	Weight	≤7.5kg
Use environment	Operating temperature	-40℃~+60℃
	Storage temperature	-45℃~+70℃
	Vibration (with damping)	5~2000Hz，6.06g
	Shock (with shock absorption)	30g，11ms
Reliability	MTBF	3000h
	Life span	> 15 years
	Continuous working time	>24h

3. Composition and working principle

3.1 System composition

Inertial navigation is mainly composed of inertial measurement unit, rotating mechanism, navigation computer, GNSS board, navigation software, DC power supply and mechanical components. The inertial measurement unit consists of three high-precision fiber-optic gyroscopes, three quartz flexible accelerometers, a navigation computer, a secondary power supply and a data acquisition circuit.



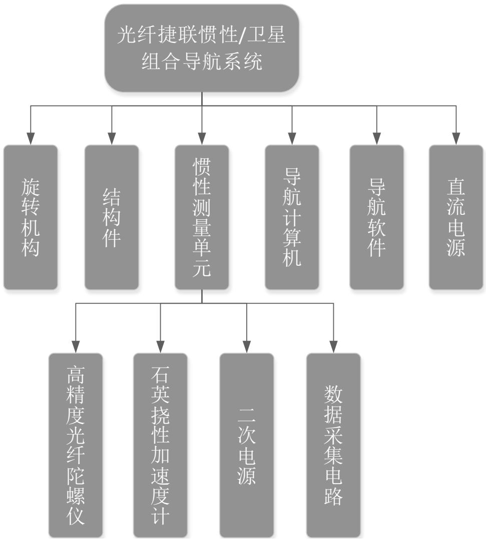


Figure 2 Inertial Navigation Main Body Figure 3 Inertial Navigation Composition

How the 3.2 works

The inertial measurement unit in the inertial navigation system uses three orthogonal high-precision fiber optic gyroscopes to sense the angular motion of the carrier and output a digital signal proportional to the angular velocity of the carrier motion; three orthogonal quartz flexible accelerometers sense the linear acceleration of the carrier and output a current signal proportional to the linear acceleration of the carrier, and the current signal is converted into a digital signal by a conversion circuit. The inertial measurement unit outputs angular velocity and acceleration information. The inertial measurement unit is installed on the rotating mechanism and rotates with the rotating mechanism, and the purpose of modulating the error of the inertial device is achieved through the reciprocating rotation of the rotating mechanism.

The GNSS board receives the satellite information, and sends the navigation result to the navigation computer after the navigation positioning calculation.

The navigation computer completes the gyroscope, accelerometer, GNSS data reception, system error compensation calculation and navigation calculation, and sends real-time navigation information such as speed, position and attitude to the outside through the interface circuit in a specified period.

The inertial navigation system has the self-north-seeking function based on the compass effect, and can measure the heading value marked by the inertial navigation system; in addition, according to the measured values of the accelerometer and the gyroscope, the horizontal attitude angle is calculated based on the static base state or the reference speed.

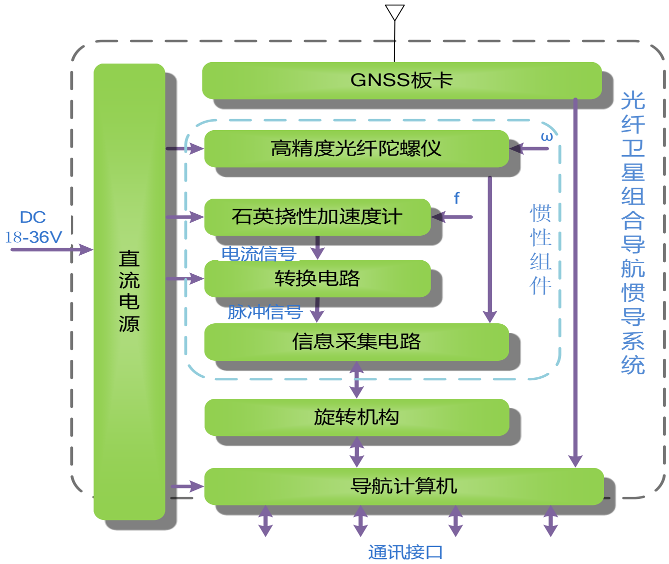


Fig. 4 Working Principle of Inertial Navigation

The rotation modulation inertial navigation is to add a rotation mechanism and an angle measuring device outside the strapdown inertial navigation system, the navigation calculation still adopts the strapdown inertial navigation algorithm, the attitude of the inertial measurement unit is directly calculated, and the attitude information of the carrier is obtained according to the rotation angle of the inertial measurement unit relative to the carrier (obtained by the angle measuring device in real time).

An example of that effect of the rotary modulation is briefly describe below.

Taking the zero bias of the horizontal gyro as an example, assuming that the zero bias of the horizontal gyro X and Z is and respectively, and the inertial navigation heading angle is, the equivalent gyro drift in the north and east directions is:

$$\begin{cases} \varepsilon_N = \varepsilon_x cos\alpha + \varepsilon_z sin\alpha \\ \varepsilon_E = -\varepsilon_x sin\alpha + \varepsilon_z cos\alpha \end{cases}$$

If the course angleαIf it remains unchanged, there is a constant equivalent north and east gyro bias, and the integration will lead to attitude errors diverging over time, which will lead to navigation velocity and position errors;

If the course angle$\alpha = \omega t$That is, the course angle changes periodically, the sine and cosine of the course angle in the above formula are zero after integral period integration, so the equivalent north and east gyro bias will not cause attitude errors that diverge with time, and play a role in modulating the gyro bias, thereby suppressing the navigation error. The modulation principle of the zero bias of the horizontal accelerometer is similar.

4 Dimensions and weight

4.1 dimensions

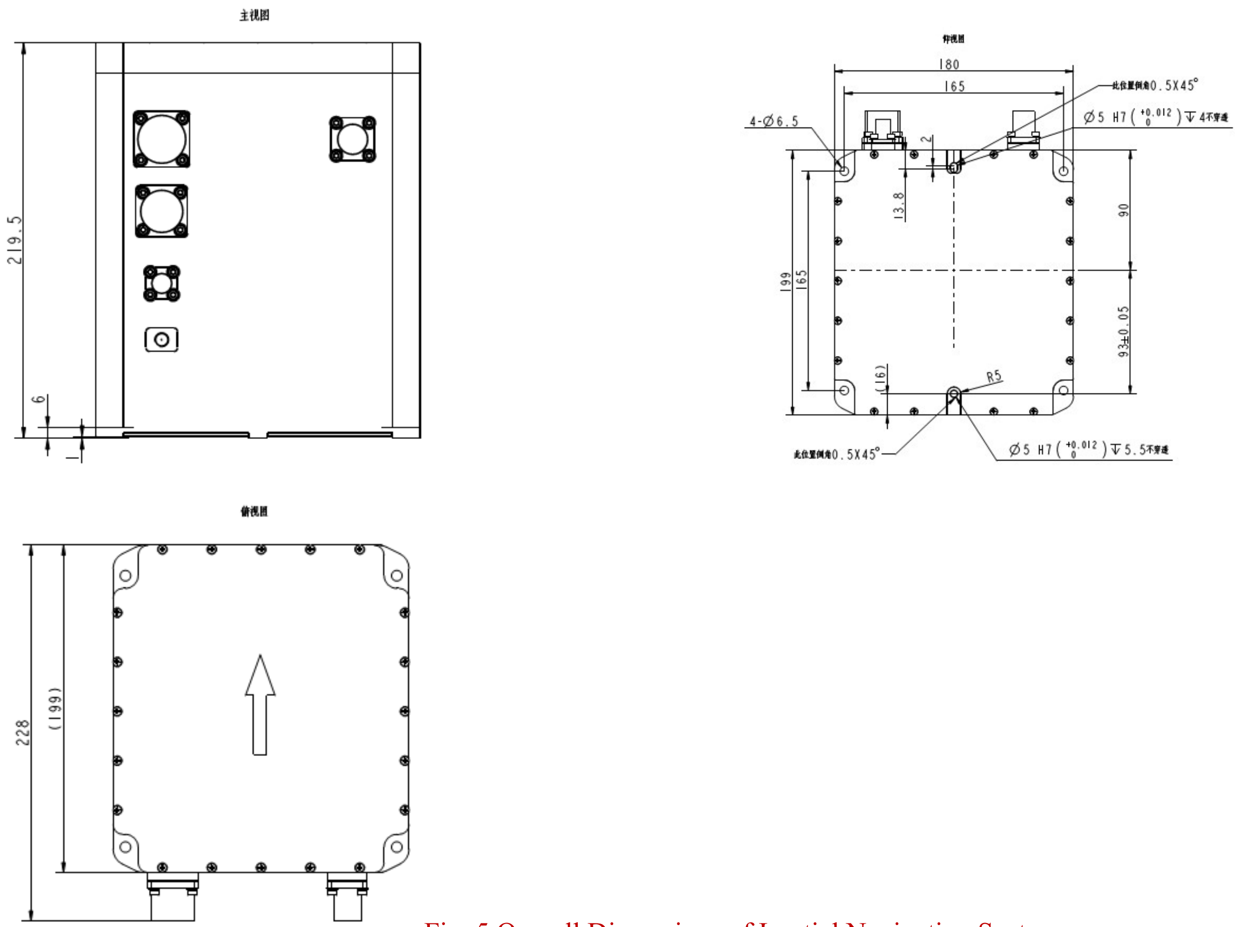


Fig. 5 Overall Dimensions of Inertial Navigation System

4.2 weight

Single set of inertial navigation is not more than 8.0 kg (航空型应用可选不大于 6.5 kg).

5 Power supply and electrical interface

5.1 Power supply

It can be powered by two power supplies, and the specific power supply characteristics are as follows:

Input voltage range 24 V to 36 V;

Transient power consumption is not more than 100 W (< 3s);

The rated power consumption is not more than 30 W.

5.2 Electrical interface

5.2.1 connector definition

There are five connection sockets on the inertial navigation connector panel, as shown in Figure 6 below.

See Appendix 1 for the connector model and point definition.

X1, X2, and X3 connector plugs are provided for delivery, and the user makes the on-board cable. One 750mm RF cable with TNC male ends at both ends shall be delivered.

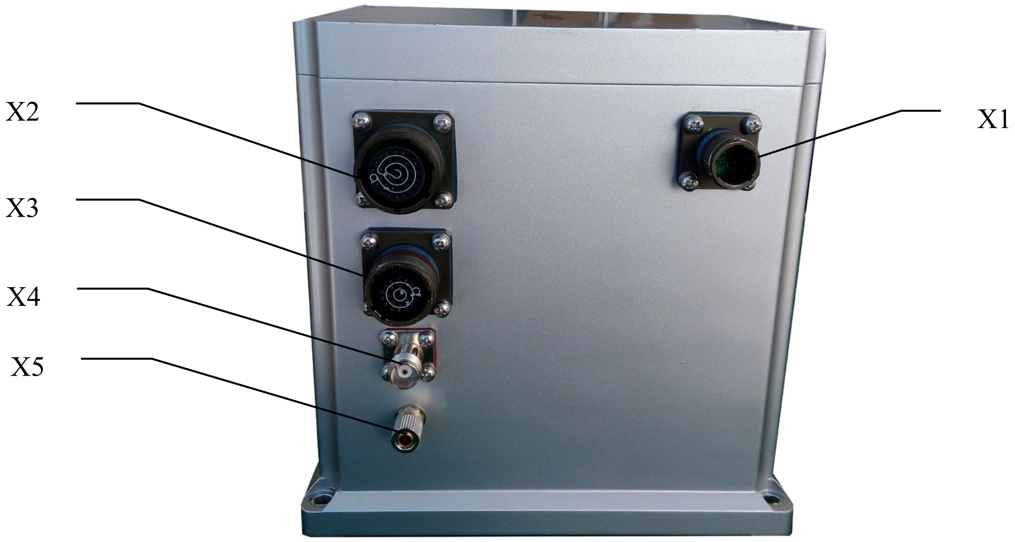


Figure 6 Schematic Diagram of Connector Labeling

5.2.2 Motor Interface and Protocol

The electrical interfaces are as follows, and the inertial navigation interface relationship is shown in Figure 7:

A) 7 RS422 interfaces, of which:

COM 1: output navigation information to the user: this interface outputs navigation information to the outside, up to 100 Hz, and the communication protocol is shown in Appendix 2;

COM2 outputs IMU information to the user: this interface outputs IMU information to the outside, up to 200Hz;

COM3, COM4 and COM5 are standby interfaces;

COM8 is the configuration and test interface.

B) 2 channels of RS232, in which COM6 can receive satellite differential information, and COM9 is the interface configured for GNSS board;

C) 1-way USB interface, which can export the internal storage data.

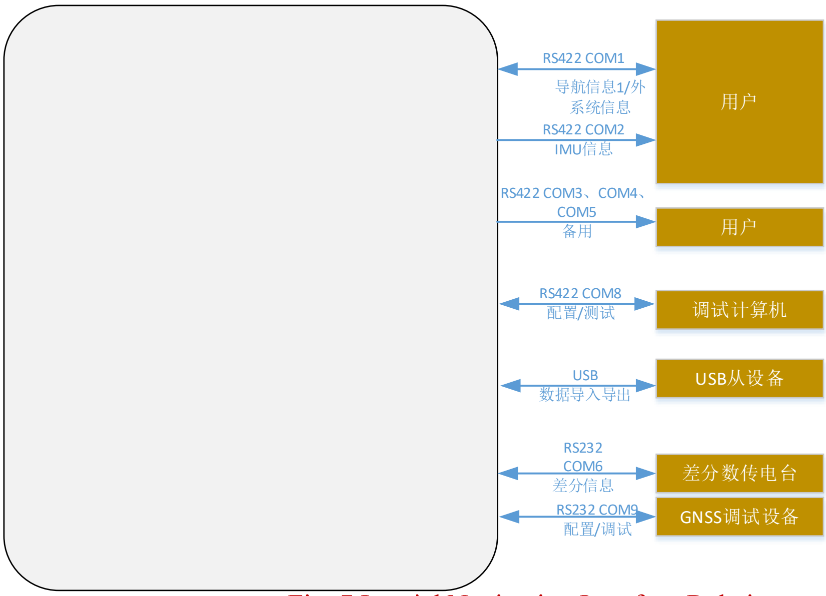


Fig. 7 Inertial Navigation Interface Relation

6 Inertial Navigation Workflow

After the inertial navigation system is powered on, the navigation software is loaded. After the loading is completed, the system self-test is performed. If the self-test fails, the self-test failure message is prompted to the outside.

If the self-test is successful, the integrated navigation process will be entered. The flow chart of inertial navigation is shown in Figure 8 below.

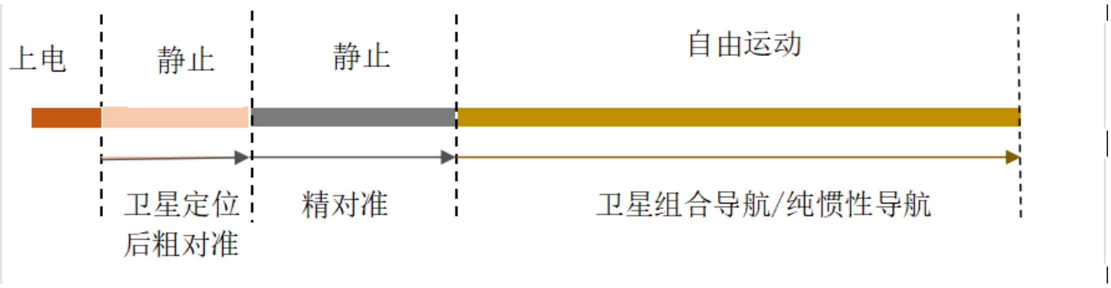


Fig. 8 Inertial Navigation Work Flow Chart

After entering the integrated navigation process, the inertial navigation system waits for valid GNSS navigation information, including longitude, latitude, altitude, speed and other information. After the binding is successful, enter the alignment state.

After 3min of alignment, the navigation information such as heading attitude is output, but the data state is invalid. After 5min of alignment, the alignment result is judged. If the alignment is successful, the navigation state is transferred. Otherwise, the alignment failure fault state is output, and the alignment is continued. When the alignment completion criterion is met, the alignment fault state word is cleared, and the integrated navigation state is transferred.

After the alignment is completed, it will turn to the navigation state to provide effective navigation information such as speed, position and attitude.

7 Installation and commissioning

7.1 Coordinate System and Direction Definition

Airframe coordinate system ("front-right-down"): X-axis is forward along the longitudinal axis of the airframe, Y-axis is rightward along the transverse axis of the airframe, and Z-axis is downward along the vertical axis of the airframe;

Geographic coordinate system- ("East-North-Sky"): east, north and sky directions are positive respectively;

Heading angle direction-roll angle is positive for roll right, pitch angle is positive for pitch up, and yaw angle is positive for yaw right.

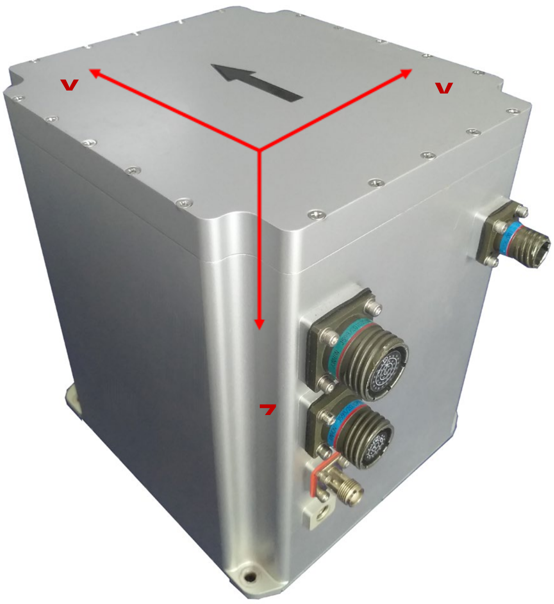


Figure 9 Definition of Coordinate System

Installation of the 7.2

The installation elements of inertial navigation system are as follows (without damping device):

The mounting end face of the inertial navigation of the a) is provided with four protruding mounting planes, through holes with the height of 1mm, the flatness of 0.01 of mm and the 惯导四个角上的安装孔直径为 6.5 of m m ;

The b) requires that the flatness of the installation base plate in the installation area not less than 205mm * 185mm is better than the 0.015 mm, and the thickness of the base plate is not less than 10mm;

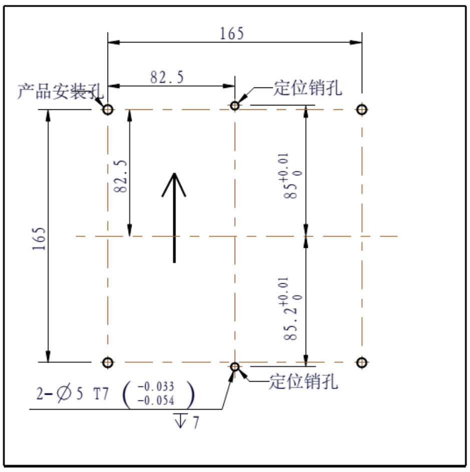
The direction of the inertial navigation arrow of the c) is the inertial navigation course, and the arrow is parallel to the longitudinal axis of the carrier during installation;

There are two positioning pin holes on the bottom surface of the d) inertial navigation system, which are used to ensure the course installation accuracy of repeated installation after disassembly. One end close to the connector is a straight waist hole, and the other end is a round hole. The hole location and positioning pin size of the inertial navigation installation base plate are shown in the following figure, where the positioning pin is inserted into the base plate during installation; The vertical plane on the right side of the inertial navigation mounting base can also be used as a mounting leaning surface to ensure the course mounting accuracy of repeated mounting after disassembly;

The e) uses 4 × M6 screws to fix the inertial navigation system on the installation base plate. The thread depth on the installation base plate is not less than 10 mm, and the installation is stable;

The space in the direction of the inertial navigation tail connector of the f) is not less than 150mm;

The relative position of the g) satellite antenna center and the inertial navigation installation center is fixed, which needs to be measured by the user, and the measurement accuracy is better than 20 mm;



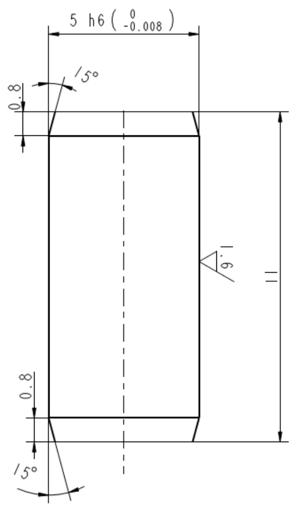


Fig. 10 Dimension of mounting baseplate Fig. 11 Dimension of locating pin

Debugging of 7.3

The inertial navigation debugging steps are as follows:

The a) inertial navigation is installed or placed on a stable installation table with good thermal conductivity;

A b) is connecte with an inertial navigation power supply cable, a communication cable and an antenna fee line, and that antenna is placed at an open and unshielded position; a com 1 port in the communication cable is connected to a test compute, so that the navigation information of the optical fiber inertial navigation can be received in real time; a direct-current stabilized voltage power supply is regulated to 28V, and the power supply current is not less than 3A;

After the c) check circuit is connected, the inertial navigation system supplies power, and the com1 port can receive the data after about 20s;

After the inertial navigation system of the d) is aligned for 600 seconds, it turns into the navigation state, and the com1 port can receive the effective navigation information;

The e) performs static navigation for 1 hour, and counts the 1-hour attitude accuracy. If the attitude and level meet the requirements, the inertial navigation system works normally;

After the f) is debugged, the inertial navigation is powered off.

8 Use and operation

The use steps are as follows:

The a) shall correctly install the inertial navigation system according to the requirements in the "Installation" section;

The b) is connected with the inertial navigation power cable, the communication cable and the antenna feeder, and the antenna is installed in the correct position; each cable is correctly connected with the user equipment; the DC power supply is 24V ~ 36V, and the power supply current is not less than 3A;

The c) checks the power supply of the inertial navigation system after the circuit is connected, and waits for about 20s before the inertial navigation system sends information to the outside;

The d) inertial navigation system waits for the effective satellite information, if the satellite information is effective, the alignment is started, the navigation state is switched to after the alignment is performed for 600 seconds, and the navigation information is sent;

Power off after the inertial navigation system of the e) is used.

9 Maintenance and service

9.1 Maintenance content

It is recommended that the inertial navigation system should be powered on once a quarter for more than 1 hour each time. In case of any fault, the fault status should be recorded accurately and reported to the manufacturer for maintenance or repair in time.

In order to ensure that the inertial navigation accuracy meets the use requirements, the parameter calibration shall be carried out every 2a (tentative), and the tentative calibration shall be returned to the factory.

9.2 Requirements for testing and using personnel

The personnel engaged in inertial navigation test and use shall carefully read the technical documents and operation instructions, master the operation essentials of the specialty, and use the equipment and tools related to the operation of the specialty.

9.3 Precautions for use of inertial navigation

Attention shall be paid to the following items during the use of inertial navigation:

The power supply interval of a) inertial navigation should not be less than 30 s to avoid repeated power supply in a short time, otherwise the internal inertial devices may be burned out;

B) inertial navigation is a precision instrument, which should avoid falling, collision and extrusion;

There is a rotating mechanism device inside the c) inertial navigation, and there will be a slight sound of motor rotation in the working process, which is a normal phenomenon.

10 Fault analysis and troubleshooting

The possible faults, fault causes and troubleshooting methods of inertial navigation are shown in the following table.

Serial number	Fault symptom	Possible causes of failure	Exclusion method
1	Startup failure: Inertial navigation is not started after being powered on, and there is no output;	Inertial navigation power supply or communication cable is not connected properly; The power supply voltage or starting current does not meet the inertial navigation requirements; Inertial navigation circuit failure;	Check whether the cable connection is loose or missing; Check whether the power supply parameters of power supply meet the requirements; After eliminating A) and B), it still does not start after being powered on for many times, and it needs to be returned to the factory for maintenance;
2	Long-term preparation state without entering the alignment state	The satellite signal of the location is poor, and the location is not determined; The satellite dish is not connected properly; Fault of receiver board;	A good satellite receive place is selected; Check whether the satellite antenna is connected correctly; After troubleshooting A) and B), the fault still occurs after being powered on for many times, and it needs to be returned to the factory

			for maintenance.
3	Alignment failed	In the process of alignment, the inertial navigation system is in a non-static state and changes its position obviously. Inertial device failure;	Ensure that the inertial navigation system is in a static state during alignment; After elimination of A), the alignment still fails after several times of power-on, and it shall be returned to the factory for repair;
4	Receiver failure	Fault of receiver software; Receiver hardware failure;	Connect the test cable, and configure and check the board through the COM9 port; if the satellite positioning of the interface is normal, check the communication between the board and the inertial navigation internal interface; If COM9 in A) is also abnormal, return to the factory for repair;
5	Gyroscope and accelerometer failure, navigation aborted	Gyroscopes and accelerometers are faulty;	Return to the factory for repair

Table 2 Fault Analysis and Troubleshooting

11 Transportation and storage

The inertial navigation system is equipped with a special packing box. Inertial navigation must be packed in a packing case during separate transportation. It shall be handled with care during disassembly and handling to avoid collision, turnover, knocking and rain. It is strictly prohibited to transport the inertial navigation with acid, alkali and other corrosive substances, volatile substances, flammable and explosive substances. The well-packed inertial navigation system can be suitable for highway, railway, waterway, aviation and other transportation.

In order to maintain higher accuracy and longer service life of the inertial navigation system as far as possible, a better storage environment shall be selected as far as possible. In general, the storage environment shall meet the following requirements: the temperature shall be 5 ℃ ~ 40 ℃, the relative humidity shall not be greater than 80%, and there shall be no corrosive substances in the warehouse.

12 Other

Appendix 1 Connector Model and Point Definition

Identification	Content	Socket model	Plug model	Mating plug tail attachment
X1	Power source	J599/20JA35PA (6-core)	J599/26JA35SA	J1784/91-09J
X2	Communication	J599/20 JD35SA (37-core)	J599/26JD35PA	J1784/91-15J
X3	Test	J599/20 JC35SN (22-core)	J599/26JC35PN	J1784/91-13J
X4	Antenna	TNC-KFB2	TNC	——
X5	Grounding column	JDZ-M5	——	——

Table 1 Connector Type (Type II)

Connector	Flight insertion point number	Signal name	Signal characteristics	Remark	Cable description
X1	1	MASK	Shielding		
	2	DC1+	1-channel power supply positive	1st power supply	Twisted pair
	3	DC1-	1-channel power supply negative		
	4	DC2+	2-way power supply positive	2nd power supply	Twisted pair
	5	DC2-	2-way power supply negative		
	6	——	——		

Table 2 Power Connector Point Definitions

Connector	Flight insertion point number	Signal name	Signal characteristics	Remark	Cable description
X2	1	RS422T1+	RS422 send +	COM 1 outputs navigation	Twisted pair shield
	2	RS422T1-	RS422 send-		

	3	RS422R1+	RS422 receiving +	information to the user	Twisted pair shield
	4	RS422R1-	RS422 receive-		
	5	RS422GND1	RS422 signal ground		
	6	MASK	Shielding		
	7	RS422T2+	RS422 send +	COM2 outputs navigation information to the user	Twisted pair shield
	8	RS422T2-	RS422 send-		
	9	RS422GND2	RS422 signal ground		
	10	RS422R2+	RS422 receiving +	Reserved	
	11	RS422R2-	RS422 receive-		
	12	RS422T3+	RS422 send +	COM3 Spare	Twisted pair shield
	13	RS422T3-	RS422 send-		
	14	RS422R3+	RS422 receiving +	Reserved	
	15	RS422R3-	RS422 receive-		
	16	RS422GND3	RS422 signal ground		
	17	MASK	Shielding		
	18	RS422T4+	RS422 send +	COM4 Spare	Twisted pair shield
	19	RS422T4-	RS422 send-		
	20	RS422R4+	RS422 receiving +	Reserved	
	21	RS422R4-	RS422 receive-		
	22	RS422GND4	RS422 signal ground		
	23	RS422T5+	RS422 send +	COM5 Spare	Twisted pair shield
	24	RS422T5-	RS422 send-		
	25	RS422GND5	RS422 signal ground		
	26	RS422R5+	RS422 receiving +	Reserved	
	27	RS422R5-	RS422 receive-		
	28	MASK	Shielding		

	29	RS232T1	RS232 transmission	Reserved	
	30	RS232R1	RS232 receive	COM6 Satellite differential interface and	
	31	RS232GND1	RS232 signal ground		
	32	PPS	PPS output	Reserved	
	33	GND	Signal ground		
	37	MASK	Shielding		

Table 3 Definition of Communication Connector Point

Connector	Flight insertion point number	Signal name	Signal characteristics	Remark	Cable description
J3	1	RS422T6+	RS422 send +	COM7 Test	Twisted pair shield
	2	RS422T6-	RS422 send-		
	3	RS422R6+	RS422 receiving +		Twisted pair shield
	4	RS422R6-	RS422 receive-		
	5	RS422GND6	RS422 signal ground		
	6	MASK	Shielding		
	7	RS422T7+	RS422 send +	COM8 Debugging	Twisted pair shield
	8	RS422T7-	RS422 send-		
	9	RS422R7+	RS422 receiving +		Twisted pair shield
	10	RS422R7-	RS422 receive-		
	11	RS422GND7	RS422 signal ground		
	12	RS232T2	RS232 transmission	COM9 GNSS board maintenance serial port	
	13	RS232R2	RS232 receive		
	14	RS232GND2	RS232 signal ground		

	15	MASK	Shielding		
	16	USB+	USB positive	USB interface (slave device)	Twisted pair shield
	17	USB-	USB negative		
	18	USB_GND	USB signal is low		
	19	USB_VDD	USB power supply		

Table 4 Test Connector Point Definitions

Appendix 2 COM1 port sends navigation information to the outside

Hardware interface features: duplex 422, baud rate 230400 bps, odd parity; external information refresh rate of 200 Hz.

Byte sequence number	Signal name	Information Coding	Range	Explain
1~2	Frame header	2 bytes, fixed content		Byte 1:0 xaa Byte 2: 0x55
3	Frame length	0x54		Number of all bytes
4	Cycle frame counter	8-bit unsigned integer	0~255	
5~8	System operating hours	32-bit unsigned integer, low byte first	0s~ +604800s	The unit is seconds LSB=0.01s MSB=42949672.96
9	System Status Word 1	8-bit character type		D1D0: Inertial navigation operating status =0:NA; = 1: preparation; = 2: alignment; = 3; Navigation D4D3D2: Navigation combination mode =0:NA; = 1: pure habit; = 4; Inertial/GNSS combination; = 6: Inertial/DGNSS combination D5: Working mode = 0: normal mode;

Byte sequence number	Signal name	Information Coding	Range	Explain
10	Spare	8-bit character type		
11	Serial port communication status word (receiving channel)	8-bit character type		D0：COM 1 Receiving channel (self-flying tube) status D1：COM 2 Receive Channel (Reserved) Status D2：COM 3 Receive Channel (Reserved) Status D3：COM 4 Receive Channel (Reserved) Status D4：COM 5 Receive Channel (Reserved) Status D5：COM 6 Receive channel (from ground simulation) status D6~7： Reserved (default 0). Value description: = 0, no received data; = 1, with received data.
12	Data valid word	8-bit character type		D 0: Horizontal attitude (pitch, roll) Data validity D1: Validity of heading data D2: Horizontal position (longitude and latitude) Data validity D3: High data availability D4: Horizontal speed (east and north) Data validity

Byte sequence number	Signal name	Information Coding	Range	Explain
				D5: celestial velocity data validity D6: validity of heading data during alignment = 0, invalid; = 1, valid.
13~14	Pitch Angle	16-bit signed integer, low byte first	-90°~ +90°	Units are in degrees LSB=0.0054931640625°
15~16	Roll Angle	16-bit signed integer, low byte first	-180°~ +180°	Units are in degrees LSB=0.0054931640625°
17~18	Heading angle	16-bit unsigned integer, low byte first	0°~ +360°	Units are in degrees LSB=0.0054931640625°
19~22	Latitude	32-bit signed integer, low byte first	-90°~ +90°	Units are in degrees LSB=0.0003017485"
23~26	Longitude	32-bit signed integer, low byte first	-180°~ +180°	Units are in degrees LSB=0.0003017485"
27~30	High altitude	32-bit signed integer, low byte first	-500m~ 12000m	The unit is meter LSB=0.01m
31~32	Eastbound speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
33~34	Northbound speed	16-bit signed integer, low byte first	-300m/s~ 300m/s	Unit is m/s LSB= 0.01m/s
35~36	Celestial speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
37~38	Flight Path Angle	16-bit unsigned integer, low byte first	0°~ +360°	Units are in degrees LSB=0.0054931640625°

Byte sequence number	Signal name	Information Coding	Range	Explain
39~40	Spare	16-bit signed integer, low byte first		
41~42	Spare	16-bit signed integer, low byte first		
43~44	Spare	16-bit signed integer, low byte first		
45	GNSS Status word	8-bit character type		D1D0: GNSS working status = 0: invalid; = 1: single point positioning; = 2: pseudorange differential positioning; = 3: RTK differential positioning. D2: Position and speed data are valid; D3: UTC time data is valid = 0, invalid; = 1, valid
46	GNSS _PDOP	8-bit unsigned integer		Unit LSB= 0.1
47~48	GNSS Eastbound speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
49~50	GNSS Northbound speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
51~52	GNSS Vertical speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
53~56	GNSS longitude	32-bit signed integer, low byte first	-180°~ +180°	Units are in degrees LSB=0.0003017485"

Byte sequence number	Signal name	Information Coding	Range	Explain
57~60	GNSS latitude	32-bit signed integer, low byte first	-90°~ +90°	Units are in degrees LSB=0.0003017485"
61~64	GNSS High altitude	32-bit signed integer, low byte first	-500m~ +10000m	The unit is meter LSB= 0.01m
65~66	UTC Time/Year	16-bit unsigned integer, low byte first	0~65536	The unit is year LSB = 1 year
67	UTC Time/Month	8-bit unsigned integer	1~12	The unit is month LSB = 1 month
68	UTC Time/Day	8-bit unsigned integer	1~31	The unit is day LSB = 1 day
69	UTC time/hour	8-bit unsigned integer	0~23	The unit is hour When LSB = 1
70	UTC Time/Min	8-bit unsigned integer	0~59	The unit is minutes LSB = 1 minute
71	UTC Time/Sec	8-bit unsigned integer	0~59	The unit is seconds LSB = 1 second
72	UTC Time/ms	8-bit unsigned integer	0~999	The unit is milliseconds LSB = 10 ms
73	GPS _ Number of stars received	8-bit unsigned integer		The unit is piece LSB＝1 MSB＝255
74	BD _ Number of stars received	8-bit unsigned integer		The unit is piece LSB＝1
75	GLONASS _ Number of	8-bit unsigned integer		The unit is piece LSB＝1

Byte sequence number	Signal name	Information Coding	Range	Explain
	Stars Received			
76	GPS _ Number of positioning stars	8-bit unsigned integer		The unit is piece LSB＝1
77	BD _ Number of positioning stars	8-bit unsigned integer		The unit is piece LSB＝1
78	GLONASS _ Number of positioning stars	8-bit unsigned integer		The unit is piece LSB＝1
79	Fault status word 1	8-bit character type		D0: X-axis gyro fault D1: Y-axis gyro fault D2: Z-axis gyro fault D3: Gyro light source failure D4: X-axis meter loading fault D5: Y-axis meter loading fault D6: Z-axis meter loading fault D7: fault of meter adding acquisition circuit = 0, normal; = 1, fault.
80	Fault status word 2	8-bit character type		D0: Power supply module 1 fault D1: Fault of power module 2 D2: Power module 3 fault D3: IMU module communication failure D4: Alignment failed D5: Data rationality failure D6 ~ 7: Reserved (default value is 0) = 0, normal;

Byte sequence number	Signal name	Information Coding	Range	Explain
				= 1, fault.
81	Reserved word	1 byte		
82	GNSS fault word	8-bit character type		D0: GNSS receiver failure; D1: GNSS antenna failure; D2 ~ 7: Reserved (default value is 0) = 0, normal; = 1, fault.
83	Software version number	8-bit unsigned number		Vx. Y; y is the value of bits D4 to D0, and X is the value of bits D7 to D5
84	Checksum	8-bit unsigned number		All preceding bytes (except the frame header) are summed to the lower 8 bits

Table 5 Protocol for sending navigation information to the outside through COM1 port

Appendix 3 IMU information sent by fiber optic inertial navigation COM2

Hardware interface features: simplex 422, baud rate 115200bps, odd parity; external information refresh rate of 200 Hz.

Explain

A) body coordinate system ("front-right-down"): X axis is forward along the vertical axis of the body, Y axis is rightward along the horizontal axis of the body, and Z axis is downward along the vertical axis of the body;

Angular rate of b): It is defined as the angular rate of rotation of the mechanical system relative to the inertial frame.

Byte sequence number	Signal name	Information Coding	Range	Explain
1~2	Frame header	2 bytes, fixed content		Byte 1:0 xaa Byte 2: 0x55

Byte sequence number	Signal name	Information Coding	Range	Explain
3	Frame identification (ID)	0 xc2 (tentative)		
4	Frame length	0x20		All Bytes (32)
5	Cycle frame counter	8-bit unsigned integer	0~255	
6	Data valid word	8-bit character type		D0: Pitch rate data availability D1: roll rate data availability D2: Yaw rate data availability D3: Longitudinal overload data validity D4: validity of lateral overload data D5: Validity of normal overload data Value description: = 0, invalid; = 1, valid.
7~10	Pitch rate	32-bit signed integer, low byte first	-400°/s~ +400°/s	Units are degrees/second LSB= 0.00000018626°/s
11~14	Roll rate	32-bit signed integer, low byte first	-400°/s~ +400°/s	Units are degrees/second LSB= 0.00000018626°/s
15~18	Yaw rate	32-bit signed integer, low byte first	-400°/s~ +400°/s	Units are degrees/second LSB= 0.00000018626°/s
19~22	Longitudinal overload (including gravity)	32-bit signed integer, low byte first	-100m/s2 ~+100m/ s2	Units are m/S2 LSB=0.000000046566 m/s2
23~26	Lateral overload (including gravity)	32-bit signed integer, low byte first	-100m/s2 ~+100m/ s2	Units are m/S2 LSB=0.000000046566 m/s2

Byte sequence number	Signal name	Information Coding	Range	Explain
27~30	Normal overload (including gravity)	32-bit signed integer, low byte first	-100m/s2 ~100m/s2	Units are m/S2 LSB= 0.000000046566 m/s2 Note: the value is -1g when the machine body is horizontal and static.
31	Reserved word	1 byte		
32	Checksum	8-bit unsigned number		All preceding bytes (except the frame header) are summed to the lower 8 bits

Table 6 Definition of IMU information data from fiber inertial navigation system to user