SENSSET
SENSOR SEQUENCE

SSI-NS611

FOG Inertial navigation system

PRODUCTS FEATURES

- Large UAV Reference INS
- Marine compass
- Self-propelled gun orientation
- Vehicle positioning and orientation
- High-precision mobile measurement
- High precision stable platform

1. Overview

SSI-NS611 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, and is realized through multi-sensor fusion and navigation calculation algorithm. It provides high-precision attitude, speed, position and other information to meet the requirements of high-precision measurement and control. Its main application fields include:

- Large UAV Reference Inertial Navigation System
- Marine compass
- Self-propelled gun orientation
- Vehicle positioning and orientation
- High-precision mobile measurement
- High precision stable platform

SSI-NS611 optical fiber integrated navigation system is divided into two configurations, SSI-NS611 A0 and SSI-NS611 B0. The electrical, structure and interface are completely the same. The difference is that the accuracy is different.

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, provide the user with navigation parameters such as position, altitude, speed, attitude, course, acceleration and angular velocity after integration, and output information such as 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 can find the north statically by pure inertia.

Key features include:

a) Initial alignment function: after the inertial navigation system is powered on, wait for the satellite information to be valid. After the satellite is valid, perform alignment for 300s. After the alignment is completed, turn to the inertial navigation system in the integrated navigation state;
b) Integrated navigation function: immediately turn to the integrated navigation state after the initial alignment, and the inertial navigation uses the internal GNSS board for integrated navigation, which can calculate the navigation information such as carrier speed, position and attitude;
c) Communication function: inertial navigation can output inertial navigation measurement information according to the protocol;
d) Capable of upgrading software in situ on the aircraft: navigation software can be upgraded through serial port;
e) With self-test capability, when the system fails, it can send invalid and alarm information to the relevant equipment;
f) It has the function of shaking alignment.

The inertial navigation workflow is shown in Figure 1 below.

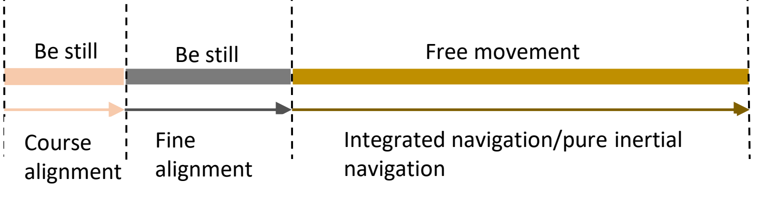

Figure 1. Inertial navigation flow chart

2.1 Main technical characteristics

Table 1. Technical parameters

Parameter	Condition	Model	
		A11	B11
Positioning accuracy	GNSS Valid, Single Point	1.2 m (RMS)	1.2 m (RMS)
	GNSS Valid, RTK	2 cm + 1 ppm (RMS)	2 cm + 1 ppm (RMS)
	Position maintenance (GNSS invalid)	1.5 nm/h (50% CEP) 5 nm/2/h (50% CEP)	0.8 nm/h (CEP) 3.0 nm/3h (CEP) (1‰D, D is for Distance)
Heading accuracy	Self-seeking north	0.1°×sec (Lati), (RMS), 10 min	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)	0.05°/h (RMS), 0.1°/2h (RMS)	0.02°/h (RMS) 0.05°/3h (RMS)
Attitude accuracy	GNSS is valid	0.03° (RMS)	0.01
	Attitude maintenance (GNSS failure)	0.02 °/h (RMS), 0.06 °/2h (RMS)	0.01 °/h (RMS) 0.03 °/3h (RMS
Speed accuracy	GNSS valid, single point L1/L2	0.1 m/s (RMS)	0.1 m/s (RMS)
	Speed maintenance (GNSS invalid)	2 m/s/h (RMS) 5 m/s/h (RMS)	0.8m/s/h (RMS) 3 m/s/3h (RMS)
Optical Fiber Gyroscope	Measuring range	±400° /s	±400° /s
	Zero bias stability	≤0.02° /h	≤0.01° /h
Quartz flexibility accelerometer	Measuring range	±20g	±20g
	Zero bias stability	≤ 50 μg (10 s average)	≤ 20 μg (10 s average)
Communication interface	RS422	Route 6 Baude rate 9.6 kpbs ~ 921.6 kbps. Default 115.2 kbps Frequency up to 1000 Hz (raw data), default 200 Hz	
	RS232	Route 1 Baud rate 9.6 kbps ~ 921.6 kbps, default 115.2 kbps Frequency up to 1000 Hz (raw data), default 200 Hz	
Electrical characteristics	Voltage	24~36 VDC	
	Power consumption	<30 W	
Structural characteristics	Size	199mm×180mm×219.5mm	
	Weight	6.5 kg	<7.5 kg (non-aviation) <6.5 kg (optional for aviation)
Use environment	Operating temperature	-40℃~+60℃	
	Storage temperature	-45℃~+65℃	
	Vibration (with damping)	5~2000Hz, 6.06g	
	Shock	30g, 11ms	
Reliability	Life span	> 15 year	
	Continuous working time	>24 h	

3. Attitude accuracy

3.1 System composition

The system includes the inertial navigation host, and the physical picture is as follows.

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 is composed of three high-precision fiber optic gyroscopes, three quartz flexible accelerometers, navigation computer, secondary power supply and data acquisition circuit, as shown in Figure 2 below.

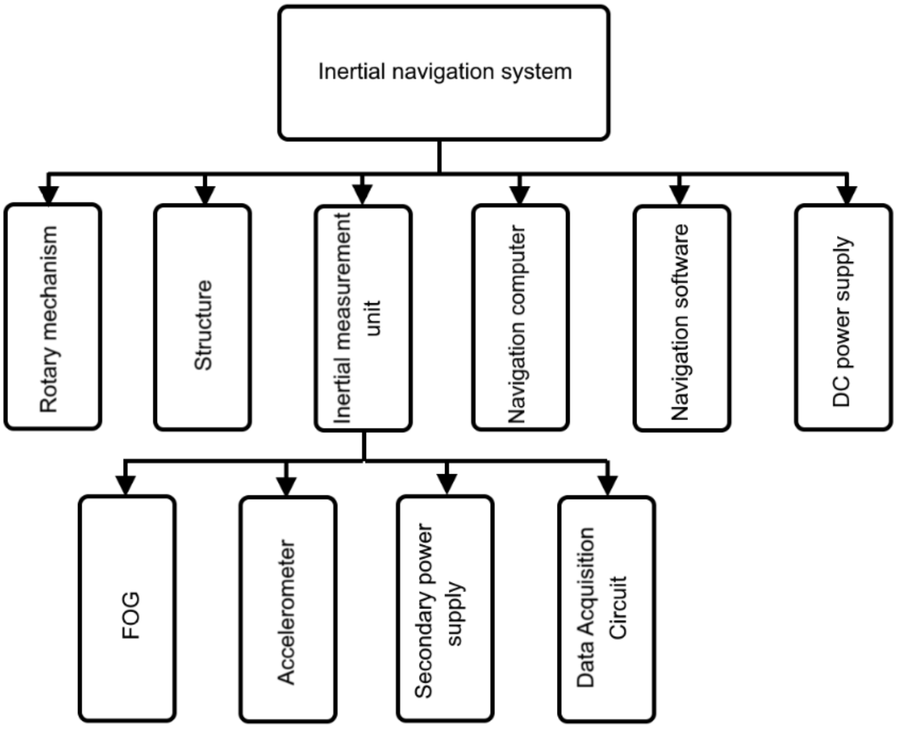

Figure 2. Inertial navigation composition

3.2 How it wotks

The inertial measurement unit inside the inertial navigation adopts three orthogonal high-precision fiber optic gyroscopes to sense the angular motion of the carrier and output a diINStal signal proportional to the angular rate of the carrier motion; Three orthogonally configured quartz flexible accelerometers sense the linear acceleration of the carrier and output a current signal proportional to the linear acceleration, and the current signal is converted into a diINStal signal through 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 course value marked by the inertial navigation system; In addition, the horizontal attitude angle is calculated based on the stationary base state or the reference speed from the measurement values of the accelerometer and the gyroscope.

The working principle of inertial navigation is shown in Figure 3.

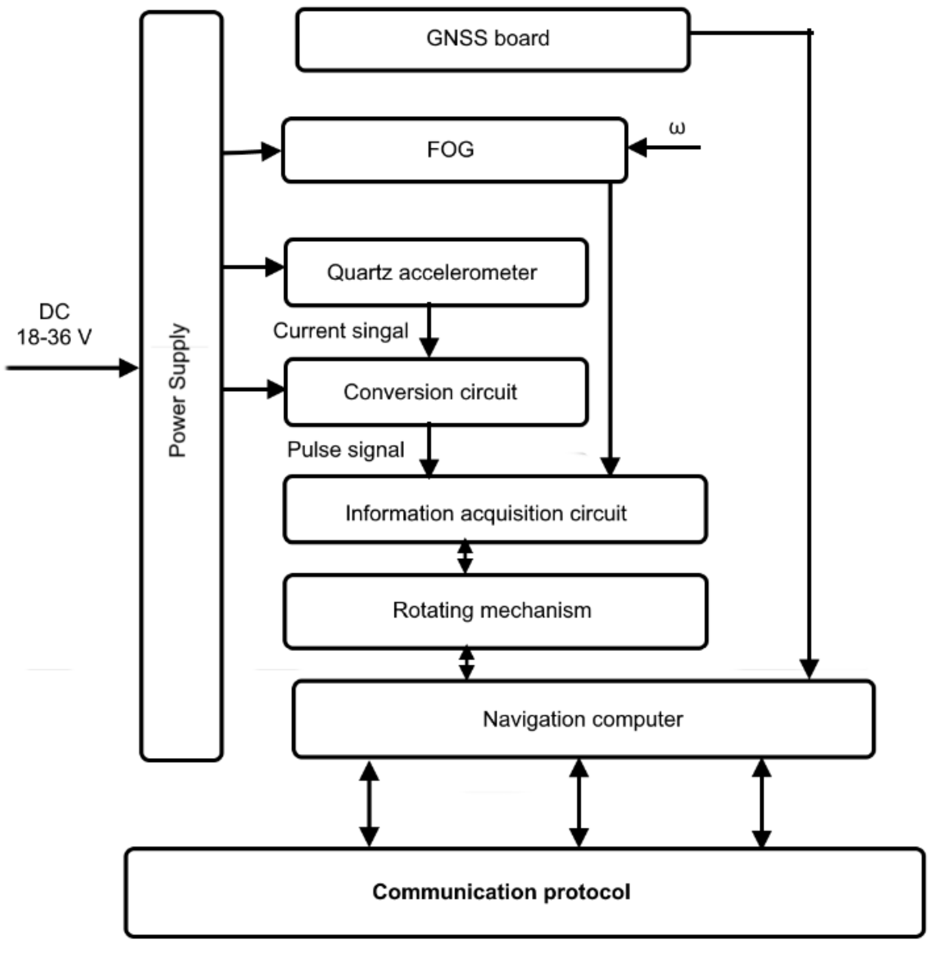

Figure 3. Schematic diagram of inertial navigation

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).

The effect of the rotary modulation is briefly described below as an example.

Take the zero bias of the horizontal gyro as an example, assume that the zero biases of the horizontal gyro X and Z are respectively ε_x and ε_z, the inertial navigation heading angle is α, then the equivalent gyroscopic drift in the north and east direction 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 angle *α* If it remains unchanged, there is a constant equivalent north and east gyro bias, and the integration will lead to attitude errors diverINSng 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 over time, and play a role in modulating gyro bias, thereby inhibiting navigation errors. The modulation principle of the zero bias of the horizontal accelerometer is similar.

4. Dimension and weight

4.1 Size

The overall dimension of the system is 199 mm × 180 mm × 219.5mm (L × W × H). See Figure 4 below for the overall dimension.

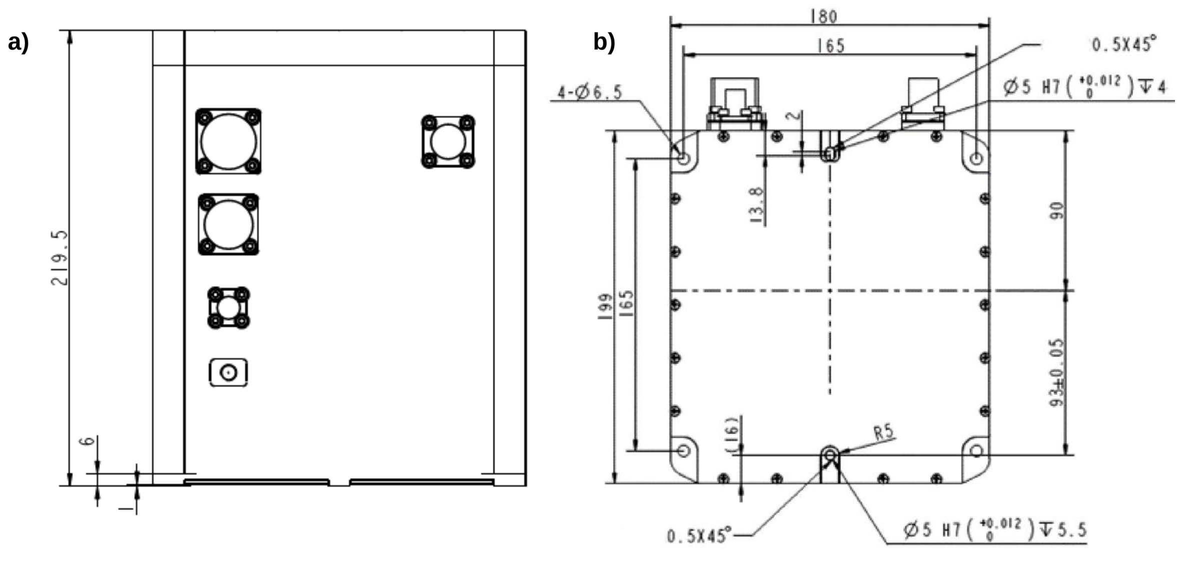

Figure 4. Mechanical dimensions. a) front view b) bottom view

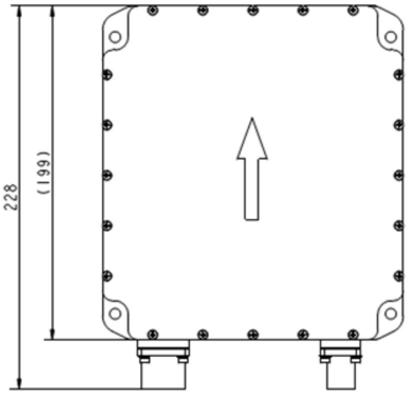

Figure 5. Mechanical dimensions (top view)

4.2 Weight

A single set of inertial navigation is not more than 8.0 kg (not more than 6.5 kg is optional for aviation applications).

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: 24V ~ 36V;
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 5 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 marking

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-way RS422 interface, 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.

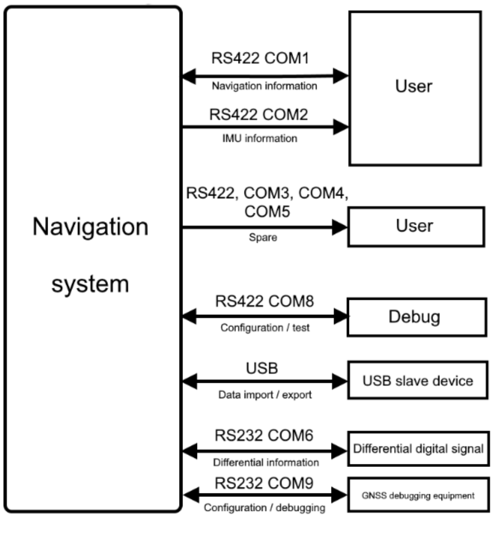

Figure 7. Inertial navigation interface diagram

6. Inertial navigation workflow

After the inertial navigation system is powered on, the navigation software is loaded. After loading, 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.

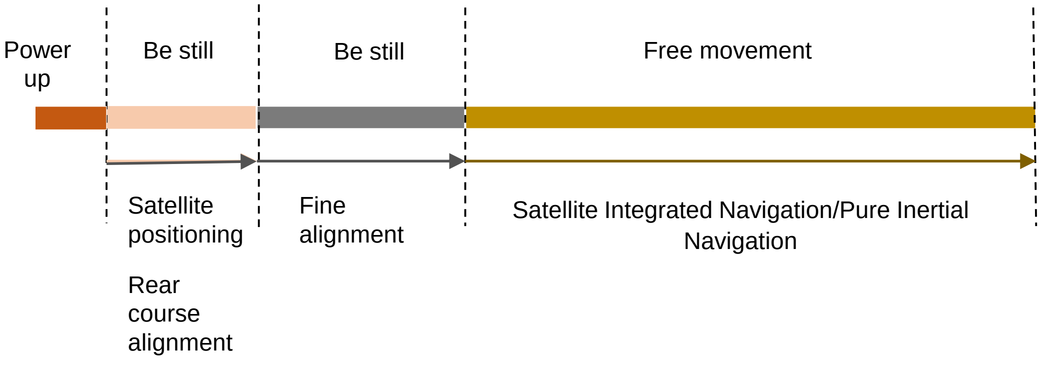

Figure 8. Inertial navigation work flow chart

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

After 3min of alignment, 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 fault state of alignment failure is output, and the alignment is continued. When the criteria for completion of alignment are met, the fault state word of alignment 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 lonINStudinal axis of the airframe, Y axis is rightward along the transverse axis of the airframe, and Z axis is downward along the vertical axis;

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

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

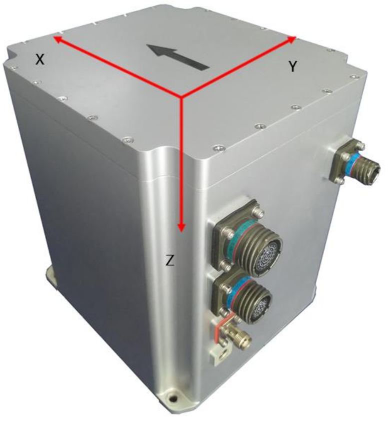

Figure 9. Coordinate system definition

7.2 Installation

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

a) The mounting end face of the inertial navigation system is provided with four protruding mounting planes, the height of each mounting plane is 1mm, the flatness of each mounting plane is 0.01mm, and the mounting holes on the four corners of the inertial navigation system are through holes with the diameter of 6.5mm;

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

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

d) The bottom surface of the inertial navigation system is provided with two positioning pin holes which are used for ensuring 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; See the following figure for the hole position of the mounting base plate of the inertial navigation system and the size of the locating pin. The locating pin is inserted into the base plate during installation. The right vertical surface 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;

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

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

g) The relative position of the 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 20mm;

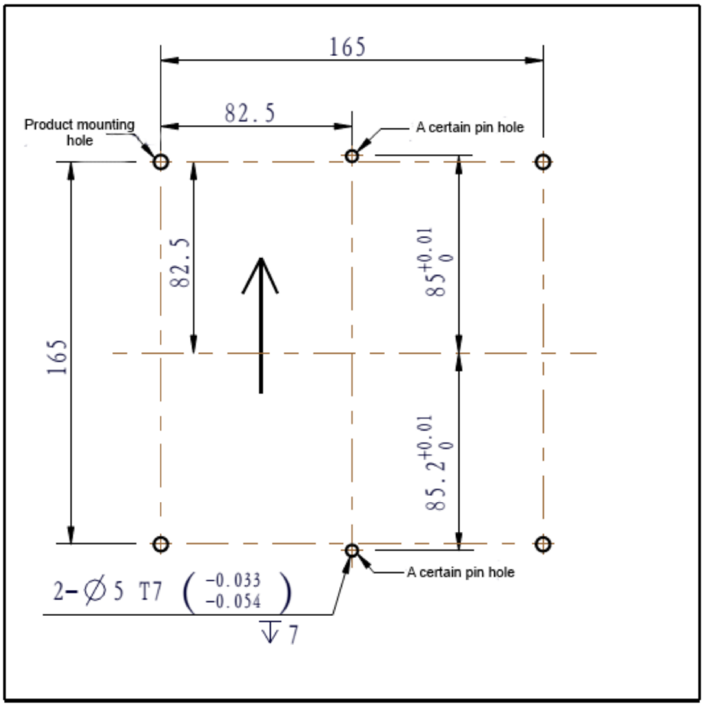

Figure 10. Mechanical dimension of mounting baseplate

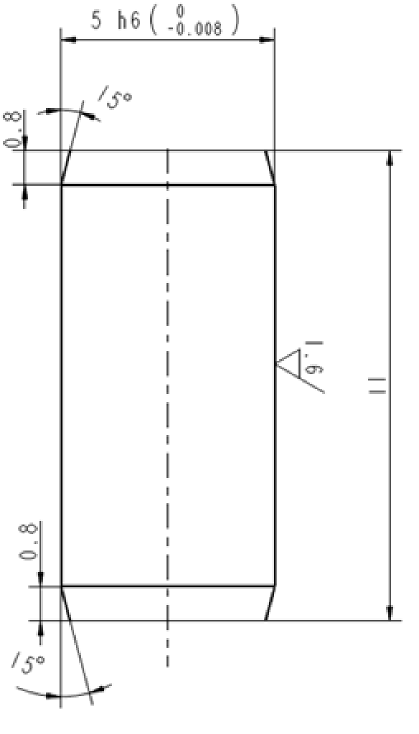

Figure 11. Mechanical dimension of dowel

7.3 DebugINSng

The inertial navigation debugINSng steps are as follows:

a) The inertial navigation system is installed or placed on a stable installation table with good thermal conductivity;
b) Connect the inertial navigation power cable, communication cable and antenna feeder, and place the antenna in an open and unshielded position; The com 1 port in the communication cable is connected to the test computer, which is convenient for receiving the optical fiber inertial navigation information in real time; Regulate the DC stabilized voltage power supply to 28V, and the power supply current shall not be less than 3A;
c) Check the power supply of the inertial navigation after the circuit is connected, and wait for about 20s before the com1 port can receive the data;
d) After the inertial navigation system is aligned for 300 s, it turns to the navigation state, and the com1 port can receive effective navigation information;
e) Static navigation for 1 hour, statistics of attitude accuracy for 1 hour, attitude and level meet the requirements, then the inertial navigation works normally;
f) After debugINSng, the inertial navigation is powered off.

8. Use and operation

8.1 Use and operation

The use steps are as follows:

a) Install the inertial navigation system correctly according to the requirements in the "Installation" section;

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

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

d) Inertial navigation waits for effective satellite information, and if the satellite information is effective, alignment is started; Turn to the navigation state after aligning for 300s, and send the navigation information;

e) Power off after the inertial navigation is used.

9. Maintenance and care

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 Maintenance content

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:

a) The power supply interval of the inertial navigation system shall not be less than 30 s to avoid repeated enerINSzation in a short time, otherwise the internal inertial devices may be burned down;
b) Inertial navigation is a precision instrument, which should avoid falling, collision and extrusion.
c) There is a rotating mechanism device inside the inertial navigation, and there will be a slight sound of motor rotation during operation, 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.

Table 2. Fault analysis and troubleshooting

Serial number	Fault symptom	Possible causes of failure	Exclusion
1	Startup failure: Inertial navigation is not started after being powered on, and there is no output;	A.Inertial navigation power supply or communication cable is not connected properly; B.The power supply voltage or starting current does not meet the inertial navigation requirements; C.Inertial navigation circuit failure;	A.Check whether the cable connection is loose or missing; B. Check whether the power supply parameters of power supply meet the requirements; C. 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	A.The satellite signal of the location is poor, and the location is not determined; B.The satellite dish is not connected properly. C.Fault of receiver board;	A. A good satellite receive place is selected; B Check whether the satellite antenna is connected correctly; C 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	A.In the process of alignment, the inertial navigation system is in a non-static state and changes its position obviously. B.Inertial device failure;	A)Ensure that the inertial navigation system is in a static state during alignment; B) 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	A.Receiver software failure; B.Receiver hardware failure;	A. 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; B. 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

11. Transportation and storage

The inertial navigation system is equipped with a special packing box. Inertial navigation must be packed in boxes during separate transportation; Handle with care during disassembly and handling to avoid collision, turnover, knocking and rain. It is strictly prohibited to transport with corrosive substances such as acid and alkali, 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 should be selected as far as possible. In general, the storage environment should meet the following requirements: the temperature should be 5 ℃ ~ 40 ℃, the relative humidity should not be greater than 80%, and there should be no corrosive substances in the warehouse.

Application 1. Connector Model and Point Definition

Table 3. Connector type (Type II)

Identification	Content	Socket model	Plug model	Mating plug tail attachment
X1	Power source	J599/20JA35PA (6-core)	J599/26JA35S A	J1784/91-09J
X2	Communication	J599/20 JD35SA (37-core)	J599/26JD35P A	J1784/91-15J
X3	Test	J599/20 JC35SN (22-core)	J599/26JC35P N	J1784/91-13J
X4	Antenna	TNC-KFB2	TNC	——
X5	Grounding column	JDZ-M5	——	——

Table 4. Power connector port definitions

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 5. Communication connections port definitions

Connector	Flight insertion point number	Signal name	Signal characteristics	Remark	Cable description
X2	1	RS422T1+	RS422 send +	COM1 Outputting navigation information to a user	Twisted pair shield
	2	RS422T1-	RS422 Sending-		
	3	RS422R1+	RS422 receive +		Twisted pair shield
	4	RS422R1-	RS422 receive-		
	5	RS422GND1	RS422 signal ground		
	6	MASK	Shielding		
	7	RS422T2+	RS422 send +	COM2 Outputting navigation information to a user	Twisted pair shield
	8	RS422T2-	RS422 Sending-		
	9	RS422GND2	RS422 signal ground		
	10	RS422R2+	RS422 receive +	Reserved	
	11	RS422R2-	RS422 receive-		
	12	RS422T3+	RS422 send +	COM3 Spare	Twisted pair shield
	13	RS422T3-	RS422 Sending-		
	14	RS422R3+	RS422 receive +	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 Sending-		
	20	RS422R4+	RS422 receive +	Reserved	
	21	RS422R4-	RS422 receive-		
	22	RS422GND4	RS422 signal ground		
	23	RS422T5+	RS422 send +	COM5 Spare	Twisted pair shield
	24	RS422T5-	RS422 Sending-		
	25	RS422GND5	RS422 signal ground		
	26	RS422R5+	RS422 receive +	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 6. Test connector port definitons

Connector	Flight insertion point number	Signal name	Signal characteristics	Remark	Cable description
X3	1	RS422T6+	RS422 send +	COM7 Test	Twisted pair shield
	2	RS422T6-	RS422 Sending-		
	3	RS422R6+	RS422 receive +		Twisted pair shield
	4	RS422R6-	RS422 receive-		
	5	RS422GND6	RS422 signal ground		
	6	MASK	Shielding		
	7	RS422T7+	RS422 send +	COM8 DebugINSng	Twisted pair shield
	8	RS422T7-	RS422 Sending-		
	9	RS422R7+	RS422 receive +		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		

Application 2. COM1 Communication protocol

Table 7. Communication protocol

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 integration; = 6: Inertial/DGNSS combination D5: Working mode = 0: normal mode;
10	Spare	8-bit character type		
11	Serial port communication status word (receiving channel)	8-bit character type		D0: COM1 receiving channel (self-flying tube) status D1: COM2 receiving channel (reserved) status D2: COM3 receiving channel (reserved) status D3: COM4 receiving channel (reserved) status D4: COM5 receiving channel (reserved) status D5: COM6 receiving channel (from ground simulation) status D6 ~ 7: reserved (default value: 0). Value description: = 0, no received data; = 1, with received data.

Byte sequence number	Signal name	Information Coding	Range	Explain
12	Data valid word	8-bit character type		D0: Level attitude (pitch, roll) data availability D1: Validity of heading data D2: Data validity of horizontal position (lonINStude and latitude) D3: High data availability D4: horizontal velocity (east and north) data availability D5: celestial velocity data availability 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	LonINStude	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°
39~40	Spare	16-bit signed integer, low byte first		
41~42	Spare	16-bit signed integer, low byte first		

Byte sequence number	Signal name	Information Coding	Range	Explain
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 velocity	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 lonINStude	32-bit signed integer, low byte first	-180°~ +180°	Units are in degrees LSB=0.0003017485"
57~60	GNSS latitude	32-bit signed integer, low byte first	-90°~ +90°	Units are in degrees LSB=0.0003017485"
61~64	GNSS altitude is high	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 LSB = 1
70	UTC time/minute	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

Byte sequence number	Signal name	Information Coding	Range	Explain
73	GPS _ star number	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 Stars Received	8-bit unsigned integer		The unit is piece LSB＝1
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: Power module 2 fault 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; = 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

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