TYPE 98 ROTARY FIBER STRAPDOWN INERTIAL NAVIGATION SYSTEM

PRODUCT DESCRIPTION

Introducing the FS100, a comprehensive system designed to provide high-precision measurement and control capabilities. This advanced system comprises several key components, including the Inertial Measurement Unit (IMU), Rotation Mechanism, Navigation Computer, GNSS Board, Navigation Software, DC Power Supply, and Mechanical Components.

The IMU, a crucial component of the FS100, consists of three high-precision fiber optic gyroscopes, three quartz flexure accelerometers, a navigation computer, a secondary power supply, and a data acquisition circuit. Leveraging a high-precision closed-loop fiber optic gyroscope, accelerometer, and high-end GNSS receiver board, the FS100 system employs cutting-edge multi-sensor fusion and navigation algorithms to deliver exceptional accuracy in attitude, velocity, and position information.

The FS100 system caters to various high-precision measurement and control requirements across multiple applications. Its key application areas include:

Large UAV Reference Inertial Guidance: The FS100 provides precise inertial guidance capabilities for large unmanned aerial vehicles (UAVs), ensuring optimal navigation and control.

Marine Compass: With its high precision and stability, the FS100 serves as an ideal compass solution for marine applications.

Self-Propelled Artillery Orientation: The FS100 system offers accurate orientation capabilities for self-propelled artillery systems, enabling precise targeting and control.

Vehicle-Based Positioning and Orientation: Utilizing the FS100, vehicles can achieve precise positioning and orientation, enhancing navigation and control in diverse environments.

High-Precision Mobile Measurement: The FS100 excels in high-precision mobile measurement scenarios, delivering accurate and reliable measurement data for a wide range of applications.

High-Precision Stable Platform: With its exceptional stability and precision, the FS100 is a perfect fit for high-precision stable platform applications, ensuring reliable and accurate performance.

Experience the pinnacle of high-precision measurement and control with the FS100, a comprehensive solution designed to meet the most demanding requirements in various industries.

MAIN FUNCTION

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

Inertial guide built-in GNSS board, when GNSS is effective inertial guide can be combined with GNSS for navigation, and provide the combined position, altitude, speed, attitude, heading, acceleration, angular velocity and other navigation parameters to the user, while outputting GNSS position, altitude, speed and other information.

When GNSS is invalid, it can enter the pure inertial mode (i.e., it has never performed GPS fusion after power on, and if it loses lock again after fusion, it belongs to the combined navigation mode) After starting, it has accurate attitude measurement function, can output pitch and roll heading, and pure inertial can be static north finding.

The main functions include

- initial alignment function: inertial guide power on and wait for the satellite information is valid, the satellite is valid for 300s alignment, alignment is completed after the transfer to the combined navigation state inertial guide;
- combined navigation function: immediately after the initial alignment into the combined navigation state, inertial guidance using the internal GNSS board for combined navigation, can solve the carrier speed, position and attitude and other navigation information;
- communication function: the inertial guide can output inertial guidance measurement information to the outside according to the protocol;
- with the ability to upgrade software in situ on board: the navigation software can be upgraded through the serial port;
- with self-detection capabilities, when the system failure, able to send invalid, warning information to the relevant equipment;
- with wobble alignment function.

The inertial guidance workflow is shown in Figure 1 below.

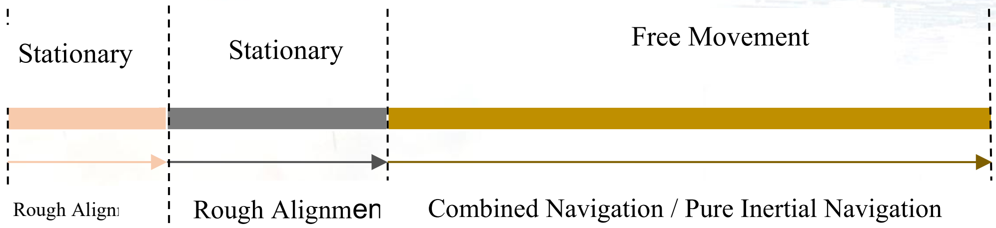

Figure 1 Inertial guidance workflow diagram

PERFORMANCE INDEX

Item	Test conditions	A0 indicator	B0 Indicator
Positioning Accuracy	GNSS valid, single point	1.2m（RMS）	1.2m（RMS）
	GNSS valid, RTK	2cm+1ppm（RMS）	2cm+1ppm（RMS）
	Position Hold (GNSS invalid)	1.5nm/h（50%CEP）, 5nm/2h（50%CEP）	0.8nm/h（CEP）, 3.0nm/3h（CEP）
Heading accuracy	Self-seeking north	0.1°×sec(Lati), Lati indicates latitude (RMS), 10min	0.03°×sec(Lati), static base 10min alignment; where Lati indicates latitude (RMS)
	Heading hold (GNSS disabled)	0.05°/h（RMS）, 0.1°/2h（RMS）	0.02°/h（RMS）, 0.05°/3h（RMS）
Attitude accuracy	GNSS valid	0.03°（RMS）	0.01°（RMS）
	Attitude hold (GNSS disabled)	0.02°/h（RMS）, 0.06°/2h（RMS）	0.01°/h（RMS）, 0.03°/3h（RMS）
Velocity accuracy	GNSS valid, single point L1/L2	0.1m/s（RMS）	0.1m/s（RMS）
	Speed hold (GNSS disabled)	2m/s/h（RMS）, 5m/s/2h（RMS）	0.8m/s/h（RMS）, 3m/s/3h（RMS）
Fiber optic	Measurement range	±400°/s	±400°/s
	Zero bias stability	≤0.02°/h	≤0.01°/h
Quartz Flexure Accelerometer	Measurement range	±20g	±20g
	Zero-offset stability	≤50µg (10s average)	≤20µg (10s average)
Communication interface	RS422	6 way Baud rate 9.6kbps~921.6kbps, default 115.2kbps Frequency up to 1000Hz (original data), default 200Hz	
	RS232	1 way Baud rate 9.6kbps~921.6kbps, default 115.2kbps Frequency up to 1000Hz (original data), default 200Hz	
Electrical Characteristics	Voltage	24～36VDC	
	Power consumption	≤30W	
Structural characteristics	Dimension	199mm×180mm×219.5mm	
	Weight	6.5kg	≤7.5kg (non-airline type)

		≤6.5kg (aviation type optional)
Operating Environment	Operating Temperature	-40℃~+60℃
	Storage temperature	-45℃~+65℃
	Vibration (with damping)	5~2000Hz，6.06g
	Shock (with damping)	30g，11ms
Reliability	Life time	>15 years
	Continuous working time	>24h

INSTRUCTIONS FOR USE

1、Product Composition

The inertial guidance mainly consists of inertial measurement unit, rotation mechanism, navigation computer, GNSS board, navigation software, DC power supply and mechanism parts. Among them, the inertial measurement unit consists of three high-precision fiber optic gyroscopes, three quartz flex accelerometers, navigation computer, secondary power supply, and data acquisition circuit, as shown in Figure 3 below.

The composition of the product is as follows Figure 1.

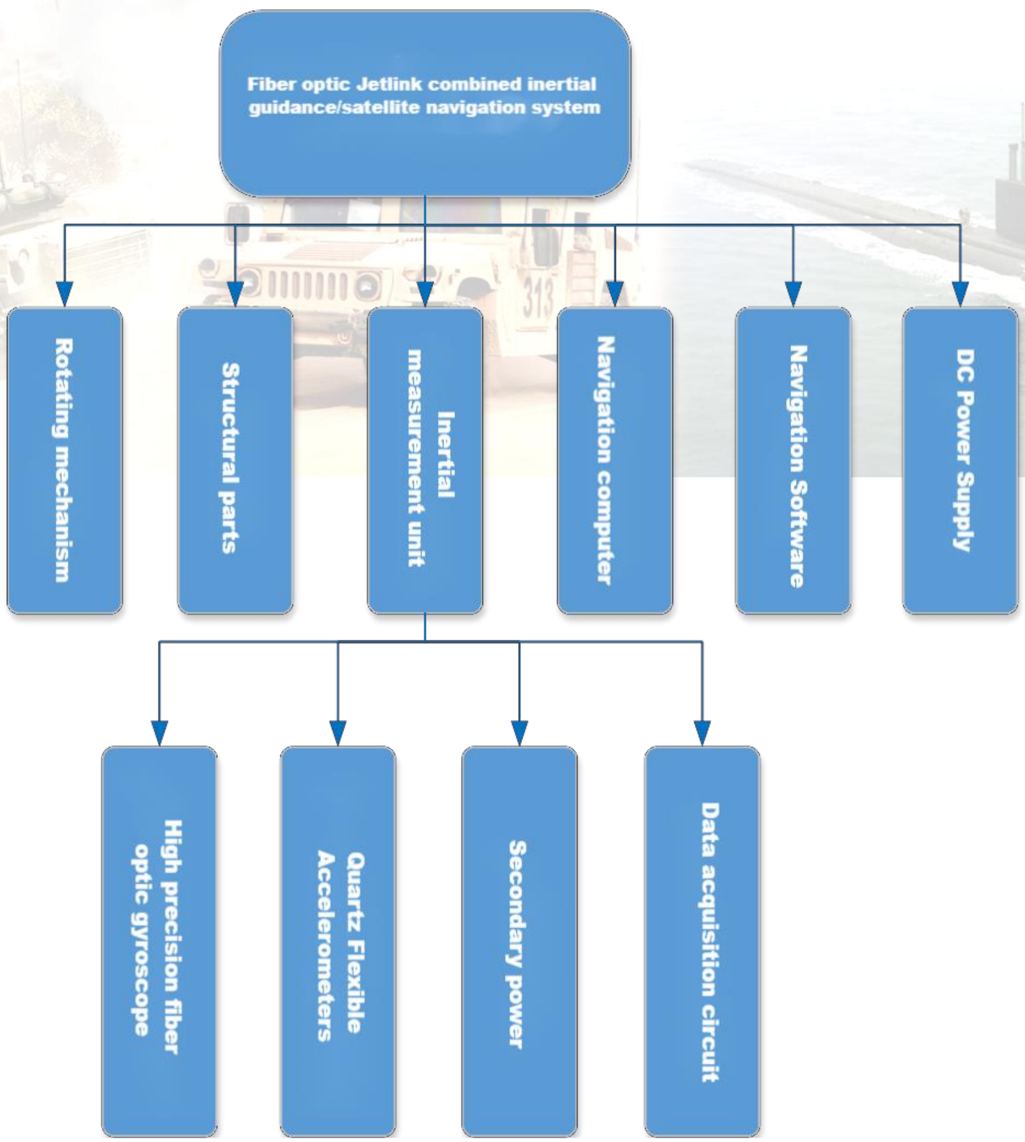

Figure 3 System Composition

2、Working Principle

The inertial measurement unit inside the inertial guide uses three high-precision fiber optic gyroscopes in orthogonal configuration to be sensitive to the angular motion of the carrier, and outputs a digital signal proportional to the angular rate of the carrier motion; three quartz flexural accelerometers in orthogonal configuration are sensitive to the linear acceleration of the carrier, and outputs a current signal proportional to it, and the current signal is converted into a digital signal by a conversion circuit. The inertial measurement unit outputs angular velocity and acceleration information externally.

The inertial measurement unit is mounted on the rotating mechanism to rotate with the rotating mechanism, and the reciprocal rotation of the rotating mechanism achieves the purpose of modulating the error of the inertial device.

The GNSS board receives the satellite information and sends the navigation result to the navigation computer after the navigation position is solved.

The navigation computer completes the gyroscope, accelerometer, GNSS data reception, system error compensation calculation, navigation solution, and sends real-time velocity, position, attitude and other navigation information through the interface circuit with a specified period.

The inertial guide has the function of self-seeking based on the "compass effect", which can measure the heading value indicated by the inertial guide; in addition, based on the accelerometer and gyroscope measurements, the horizontal attitude angle is calculated based on the static base state or reference velocity.

The working principle of the inertial guidance is shown in Figure 4.

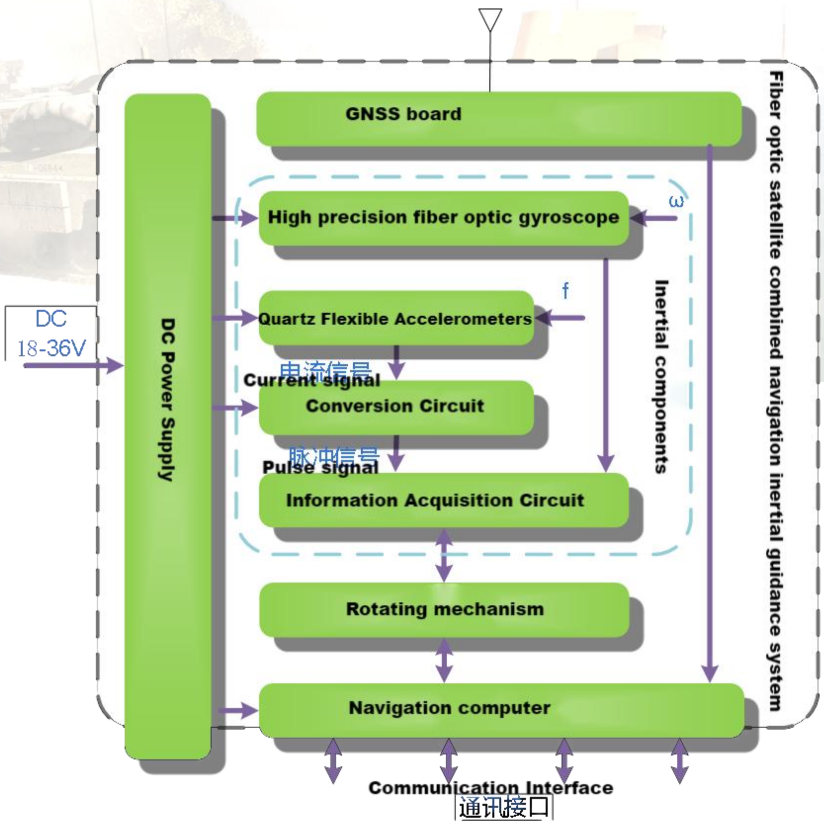

Figure 4 Inertial guidance working principle diagram

Rotationally modulated inertial guidance is to add a translational mechanism and goniometric device to the outside of the Jetlink inertial guidance system. The navigation solution still uses the Jetlink inertial guidance algorithm, which directly solves the attitude of the inertial measurement unit and obtains the attitude information of the carrier according to the rotation angle of the inertial measurement unit relative to the carrier (obtained in real time by the goniometric device).

The following is an example to briefly illustrate the effect of rotation modulation.

Take the horizontal gyro zero offset as an example, suppose the zero offset of horizontal gyro X and Z are ε_x and ε_z respectively, and the inertial navigation direction angle is, then the equivalent gyro drift of north direction 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 heading angle α remains constant, there is a constant equivalent north and east gyro zero bias, and the integration yields dispersive attitude errors over time, which in turn cause navigation velocity and position errors;

If the heading angle $\alpha = \omega t$, i.e., the heading angle varies periodically, the sine cosine integral period of the heading angle in the above equation is zero after integration, so the equivalent north and east gyro zero bias will not cause the attitude error dispersion with time, which plays the role of modulating the gyro zero bias, thus suppressing the navigation error. The modulation principle of the horizontal accelerometer zero bias is similar to this.

3、Size and weight

3.1、Size

The external dimension of the system is 199mm×180mm×219.5mm (L×W×H), and the external dimension diagram is shown in Figure 5 below.

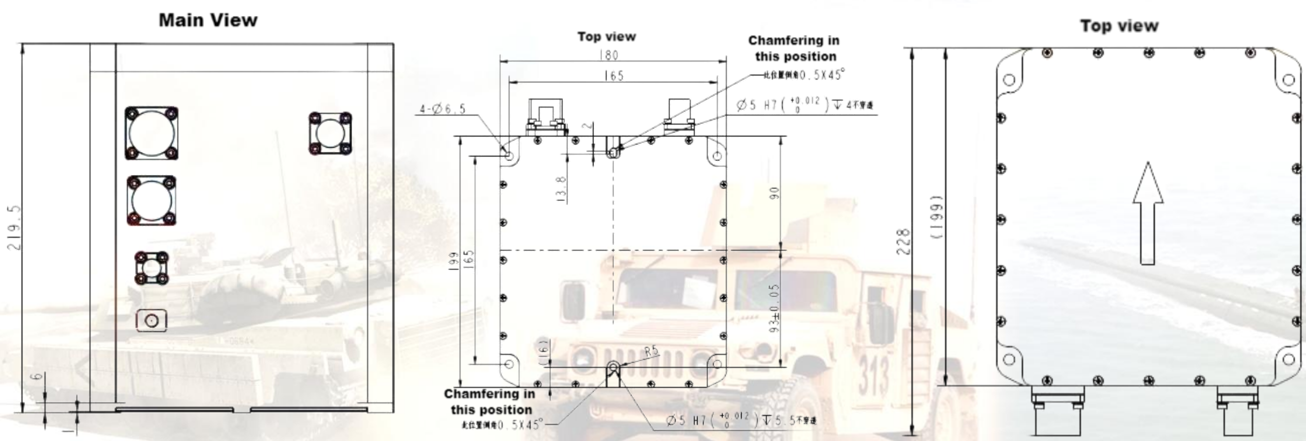

Figure 5 Inertial guidance system form factor diagram

3.2、Weight

Not more than 8.0kg for a single set of inertial guides (optionally not more than 6.5kg for aero-type applications).

4、Power supply and electrical interface

4.1 、Power supply

Dual power supply is available, and the specific power supply characteristics are as follows:

Input voltage range from 24V to 36V;

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

Rated power consumption is no more than 30W.

4.2、Electrical Interface

4.2.1、 Connector Definition

There are 5 connection sockets on the inertial guidance connector panel as shown in Figure 6 below, see Appendix 1 for each connector type and point definition.

The X1, X2 and X3 connector plugs are provided at delivery, and the user makes his own on-board cable. A 750mm length RF cable with TNC male connectors on both ends is provided for delivery.

Figure 1 Connector labeling schematic

4.2.2 \Motor interfaces and protocols

The electrical interfaces are as follows, and the inertial guide interface relationships are shown in Figure 7:

- 7-way RS422 interface, of which:

COM1: output navigation information to the user: this interface outputs navigation information externally, up to 100Hz, see Appendix 2 for communication protocols;

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

COM3, COM4, COM5 are backup interfaces;

COM8 is the configuration and test interface.

- 2-channel RS232, of which COM6 can receive satellite differential information and COM9 is the GNSS board configuration interface;
- 1-channel USB interface, which can be used for internal storage data export.

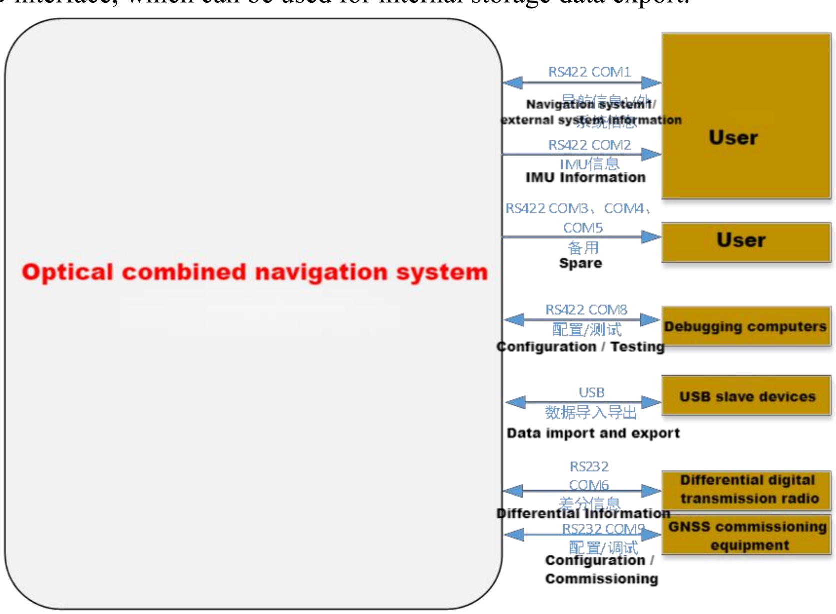

Figure 7 Inertial guidance interface relationship

5、Inertial guidance workflow

After the inertial guide is powered on, the navigation software is loaded, and the system self-test is performed after loading. Self-test success, then enter the combined navigation process. Inertial guide workflow diagram is shown in Figure 8 below.

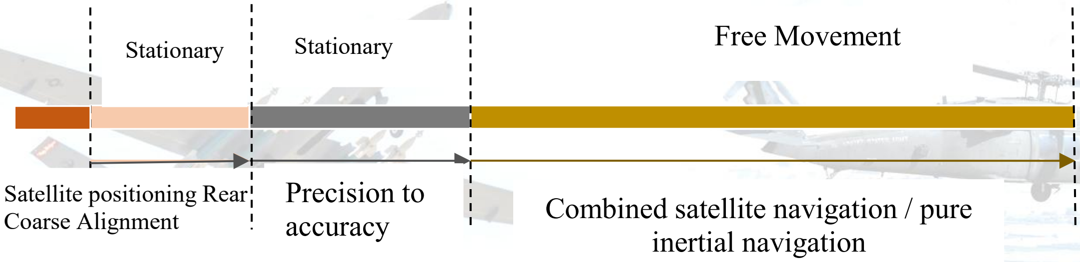

Figure 8 Inertial guidance workflow diagram

After entering the combined navigation process, the inertial guide waits for valid GNSS navigation information, including longitude, latitude, altitude, speed, etc. After successful binding, it enters the alignment state.

After 3min of alignment, the external output of navigation information such as heading, but the data state is invalid. After 5min of alignment, the alignment result is judged, if the alignment is successful, it is transferred to the navigation state, otherwise the external output of alignment failure fault state, continue the alignment, and when the alignment completion criterion is satisfied, the alignment failure state word is cleared and transferred to the combined navigation state.

When the alignment is completed, the alignment fault status word is cleared and the navigation state is transferred to the combined navigation state.

6、Installation and commissioning

6.1 、Coordinate system and direction definition

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

Geographical coordinate system - ("east-north-sky"): eastward, northward and skyward are positive, respectively;

Navigation attitude angle direction - horizontal roll angle right roll is positive, pitch angle up is positive, yaw angle right deviation is positive.

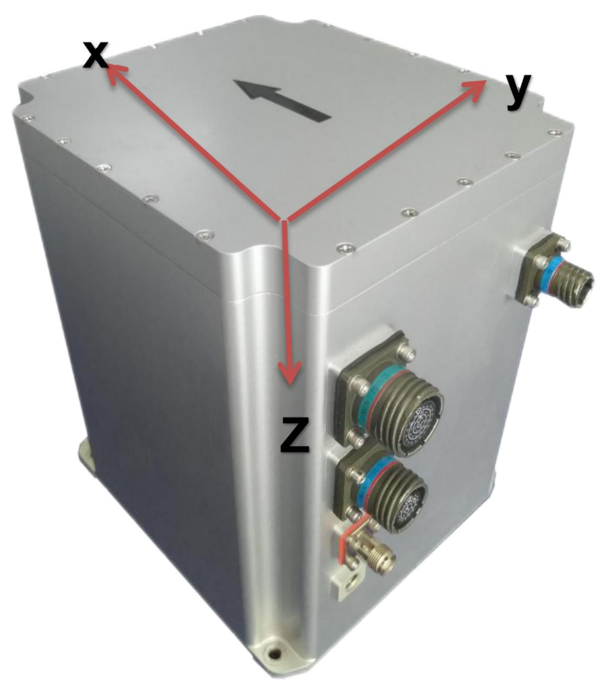

Figure 9 Coordinate system definition

6.2\ Mounting

The inertial guide mounting elements are as follows (without shock absorbers):

- Four protruding mounting planes on the mounting end face of the inertial guide with a height of 1mm and a flatness of 0.01mm, and mounting holes on the four corners of the inertial guide with a through hole diameter of 6.5mm;
- Require the mounting base plate in the installation area of not less than 205mm * 185mm flatness better than 0.015mm, the thickness of the base plate is not less than 10mm;
- Inertial guide arrow direction is inertial navigation direction, the arrow is parallel to the carrier longitudinal axis when installed;
- Inertial guide bottom surface has two positioning pin holes, used to ensure that after disassembly and repeat installation of the heading installation accuracy, near the connector end for a word waist hole, the other end for the round hole; inertial guide installation base plate hole position and positioning pin size shown in the figure below, where the positioning pin in the installation pin into the base plate; inertial guide installation base of the right vertical surface can also be used as a mounting surface to ensure that after disassembly and repeat installation of the heading installation accuracy;;
- The use of 4 × M6 screws to fix the inertial guide on the mounting base plate, the depth of the thread on the mounting base plate is not less than 10mm, the installation is stable;
- Inertial guide tail connector direction space of not less than 150mm;
- Satellite antenna center point and inertial guide installation center point relative position fixed, need user measurement given, measurement accuracy better than 20mm.

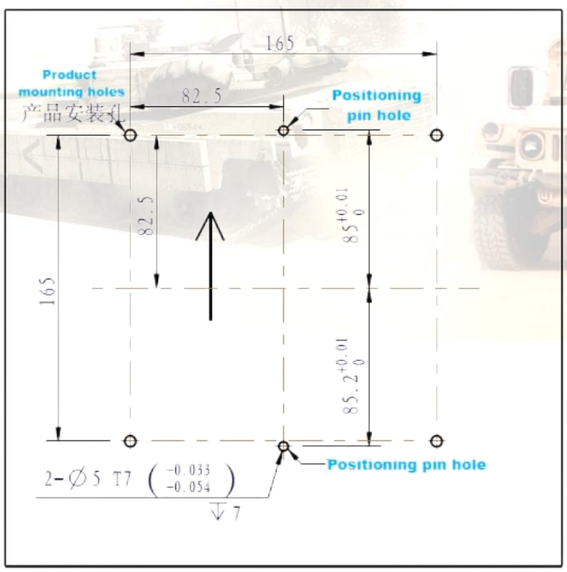

Figure 10 Installation base plate empty space dimension diagram

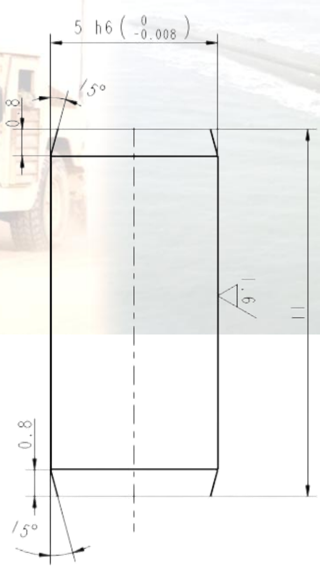

Figure 11 Positioning pin dimensions

6.3、 debugging

The commissioning steps of the inertial guide are as follows:

- Install or place the inertial guide on a stable and thermally conductive mounting table;
- Connect the inertial conductor cable, communication cable and antenna feeder, place the antenna in an open and unobstructed location; connect the com1 port in the communication cable to the test computer to facilitate real-time collection of fiber optic inertial guidance navigation information; DC regulated power supply to 28V, the supply current is not less than 3A;;
- Check the circuit is connected after the inertial guide power supply, wait for about 20s after the com1 port that can receive the data;
- Inertial guidance alignment 300s after the transition to the navigation state, com1 port can receive effective navigation information;
- Static navigation 1h, statistics 1h attitude accuracy, attitude and level to meet the indicators to go, the inertial guidance is working properly;

- After debugging, the inertial guide power off.

7、 Use and operation

7.1、 Combined navigation working mode

The steps for use are as follows:

- Install the inertial guide correctly according to the requirements in the section "Installation";
- Connect the inertial conductor cable, communication cable and antenna feeder, the antenna is installed in the correct position; each cable is connected to the user equipment correctly; DC power supply 24V~36V, power supply current is not less than 3A;
- Check the circuit is connected after the inertial guide power supply, wait about 20s after the inertial guide to send information to the outside;
- Inertial guide waiting for valid satellite information, if the satellite information is valid, then start to align; align 300s after switching to the navigation state, send navigation information;
- Inertial guide power off at the end of use.

8、 Maintenance and repair

8.1 、Maintenance content

It is recommended that the inertial guide quarterly power on, each power on time more than 1h, if there is a fault, need to accurately record the fault state, timely report to the contractor maintenance or repair.

In order to ensure that the inertial guide accuracy to meet the requirements of use, every 2a (tentative) for a parameter calibration, tentative calibration needs to return to the factory for calibration.

8.2 、Requirements for test and use personnel

The personnel engaged in the test and use of inertial guidance, need to carefully read the technical documents and operating instructions, proficient in the operation of this specialty, proficient in the use of equipment and tools related to the operation of this specialty.

8.3、 Inertial guide use precautions

Inertial guide use process need to pay attention to the following matters:

- Inertial guide power supply interval of not less than 30s, to avoid repeated power up for a short time, otherwise it may cause internal inertial devices burned;
- Inertial guide is a precision instrument, should avoid dropping, collision and extrusion;
- Inertial guide with internal rotating mechanism devices, the work process will have a slight motor rotation sound, is a normal phenomenon.

9 、Fault Analysis and Troubleshooting

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

Table 2 Fault analysis and troubleshooting

Serial number	Failure phenomenon	Possible causes of failure	Exclusion method
1	Start-up faults: (a) The inertial guide does not start after powering up, without any output;	● Inertial conductivity source or communication cable is not connected; ● The supply voltage or starting current does not meet the inertia requirements; ● Faulty inertial conductivity circuit;	● Check whether the cable connection is loose or missing plug; ● Check whether the power supply parameters meet the requirements; ● (A) and B) after the exclusion of repeated power on still does not start, need to return to the factory for repair；
2	Long-term readiness, not in alignment	● Poor satellite signal at the location, not positioning; ● The satellite antenna is not	● Select a good place for satellite reception; ● Check whether the satellite antenna is connected correctly;

		connected properly; ● Receiver board failure;	● Exclude A) and B) after repeated power on still out of order, need to return to the factory repair
3	Alignment failure	● During the alignment process, the inertial guide is in a non-stationary state and undergoes a significant position change. ● Inertial device failure;	● Ensure that the inertial guide is at rest during alignment; ● Exclude A) after repeated power-ups still alignment failure, return to factory for repair;
4	Receiver failure	● Receiver software failure; ● Receiver hardware failure;	● Connect the test cable, through the COM9 port for board configuration and check; if the interface satellite positioning is normal, then check the board and inertial guide internal interface communication; ● If COM9 in A) is also abnormal, it needs to be returned to the factory for repair;
5	Gyroscope and accelerometer failure, navigation aborted	The occurrence of faulty gyroscope and accelerometer conditions;	Return to factory for repair

10 、Transport and storage

The inertial guide is equipped with a special packing box. Inertial guide in the process of individual transportation must use the box; in the disassembly and handling should be carefully placed, avoid collision, overturning, knocking and rain, and acid, alkali and other corrosive substances, volatile substances, flammable and explosive substances are strictly prohibited in the transport together. Well-packaged inertial guide can be suitable for highway, railroad, waterway, air transport, etc.

In order to make the inertial guide as high as possible to maintain high precision and a long service life, should try to choose a better storage environment, in general, storage should be consistent with: the temperature of 5 ℃ ~ 40 ℃, relative humidity is not more than 80%, no corrosive substances in the warehouse.

11、Appendix

Appendix 1 Connector Model and Point Definition

Table 1 Connector model number (Type II)

Marking	Content	Socket Model	Plug type	Mating plug end attachment
X1	Power Supply	J599/20JA35PA（6 cores）	J599/26JA35SA	J1784/91-09J
X2	Communication	J599/20JD35SA（37 cores）	J599/26JD35PA	J1784/91-15J
X3	Test	J599/20JC35SN（22 cores）	J599/26JC35PN	J1784/91-13J
X4	Antenna	TNC-KFB2	TNC	——
X5	Grounding posts	JDZ-M5	——	——

Table 2 Power connector point definition

Connector	**Aerial insertion point number**	Signal Name	Signal Characteristics	**Remarks**	**Cable description**
X1	1	MASK	Shielding		
	2	DC1+	1-way power positive	1st power supply	Twisted pair
	3	DC1-	1 way power negative		
	4	DC2+	2-way power positive	2nd power supply	Twisted pair
	5	DC2-	2-way power negative		
	6	——	——		

Table 3 Definition of communication connector points

Connector	Aerial insertion point number	Signal Name	Signal Characteristics	Remarks	Cable description
X2	1	RS422T1+	RS422 Send+	COM1 Output navigation information to the user	Twisted Shield
	2	RS422T1-	RS422 send-		
	3	RS422R1+	RS422 Receive+		Twisted Shield
	4	RS422R1-	RS422 Receive-		
	5	RS422GND1	RS422 Signal Ground		
	6	MASK	Shield		
	7	RS422T2+	RS422 Send+	COM2 Output navigation information to the user	Twisted Shield
	8	RS422T2-	RS422 transmit-		
	9	RS422GND2	RS422 signal ground		
	10	RS422R2+	RS422 Receive+	Reserved	
	11	RS422R2-	RS422 Receive-		
	12	RS422T3+	RS422 Send+	COM3 standby	Twisted Shield
	13	RS422T3-	RS422 send-		
	14	RS422R3+	RS422 Receive+	Reserved	
	15	RS422R3-	RS422 Receive-		
	16	RS422GND3	RS422 Signal Ground		
	17	MASK	Shield		
	18	RS422T4+	RS422 transmit+	COM4 Spare	Twisted Shield
	19	RS422T4-	RS422 Transmit-		
	20	RS422R4+	RS422 Receive+	Reserved	
	21	RS422R4-	RS422 Receive-		
	22	RS422GND4	RS422 signal ground		
	23	RS422T5+	RS422 Send+	COM5 Alternate	Twisted Shield
	24	RS422T5-	RS422 send-		
	25	RS422GND5	RS422 signal ground		
	26	RS422R5+	RS422 Receive+	Reserved	
	27	RS422R5-	RS422 Receive-		
	28	MASK	Shield		
	29	RS232T1	RS232 Transmit	Reserved	
	30	RS232R1	RS232 Receive	COM6 Satellite differential interface with	
	31	RS232GND1	RS232 Signal Ground		
	32	PPS	PPS Output	Reserved	
	33	GND	Signal ground		
	37	MASK	Shield		

Table 4 Test connector point definition

Connector	Aerial insertion point number	Signal Name	Signal characteristics	Remarks	Cable description
J3	1	RS422T6+	RS422 transmit +	COM7 Test	Twisted Shield
	2	RS422T6-	RS422 transmit-		
	3	RS422R6+	RS422 Receive+		Twisted Shield
	4	RS422R6-	RS422 Receive-		
	5	RS422GND6	RS422 signal ground		
	6	MASK	Shield		
	7	RS422T7+	RS422 Send+	COM8 Debugging	Twisted Shield
	8	RS422T7-	RS422 send-		
	9	RS422R7+	RS422 Receive+		Twisted Shield
	10	RS422R7-	RS422 Receive-		
	11	RS422GND7	RS422 Signal Ground		
	12	RS232T2	RS232 Transmit	COM9 GNSS board maintenance serial port	
	13	RS232R2	RS232 Receive		
	14	RS232GND2	RS232 Signal Ground		
	15	MASK	Shield		
	16	USB+	USB Positive	USB interface (slave device)	Twisted Shield
	17	USB-	USB Negative		

	18	USB_GND	USB Signal Low		
	19	USB_VDD	USB Power		

Appendix 2 COM1 port to send external navigation information

Table 5 COM1 port external sending navigation information protocol

Byte Serial Number	Signal name	Information encoding	**Scope**	**Description**
1~2	Frame header	2 bytes, fixed content		Byte 1: 0xaa Byte 2：0x55
3	Frame length	0x54		Number of all bytes
4	Circular frame counter	8-bit unsigned integer	0~255	
5~8	System operating time	32-bit unsigned integer, lower byte first	0s~ +604800s	Unit is second LSB=0.01s MSB=42949672.96
9	System status word 1	8-bit character type		D1D0: inertial guidance operating state =0: NA; =1: preparation; =2: alignment; =3; navigation D4D3D2: Navigation combined mode =0: NA; =1: pure inertial; =4; combined inertial/DGNSS; =6: inertial/DGNSS combination D5: operating mode =0: normal mode;
10	Alternate	8-bit Character Type		
11	Serial communication status word (receive channel)	8-bit character type		D0: COM1 receive channel (self-flying tube) status D1: COM2 receive channel (reserved) status D2: COM3 receive channel (reserved) status D3: COM4 receive channel (reserved) status D4: COM5 receive channel (reserved) status D5: COM6 receive channel (from ground emulation) status D6~7: reserved (default value 0) Value description: =0, no receive data; =1, with receive data.
12	Data valid word	8-bit character type		D0: Horizontal attitude (pitch, roll) data validity D1: heading data validity D2: horizontal position (longitude, latitude) data validity D3: Altitude data validity D4: Horizontal velocity (east, north) data validity D5: Skyward velocity data validity D6: heading data validity during alignment =0, invalid; =1, valid.

Byte Serial Number	Signal name	Information encoding	Scope	Description
13~14	Pitch angle	16-bit signed integer, low byte first	-90°~ +90°	Unit in degrees LSB=0.0054931640625°
15~16	Traverse angle	16-bit signed integer, low byte first	-180°~ +180°	Unit in degrees LSB=0.0054931640625°
17~18	Heading angle	16-bit unsigned integer, low byte first	0°~ +360°	Unit in degrees LSB=0.0054931640625°
19~22	Latitude	32-bit signed integer, low byte first	-90°~ +90°	Unit in degrees LSB=0.0003017485"
23~26	Longitude	32-bit signed integer, low byte first	-180°~ +180°	Unit in degrees LSB=0.0003017485"
27~30	Altitude	32-bit signed integer, low byte first	-500m~ 12000m	Unit is meter LSB=0.01m
31~32	Eastward speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
33~34	Northward speed	16-bit signed integer, low byte first	-300m/s~ 300m/s	Unit is m/s LSB= 0.01m/s
35~36	Skyward speed	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
37~38	Track angle	16-bit unsigned integer, low byte first	0°~ +360°	Unit in degrees LSB=0.0054931640625°
39~40	Alternate	16-bit signed integer, low byte first		
41~42	Alternate	16-bit signed integer, low byte first		
43~44	Alternate	16-bit signed integer, low byte first		
45	GNSS Status Word	8-bit character type		D1D0: GNSS operating status =0: invalid; =1: single-point positioning; =2: pseudo-range differential positioning; =3: RTK differential positioning. D2: position-velocity data valid; D3: UTC time data valid =0, invalid; =1, valid

Byte Serial Number	Signal name	Information encoding	Scope	Description
46	GNSS_PDOP	8-bit unsigned integer		Unit LSB= 0.1
47~48	GNSS eastward velocity	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
49~50	GNSS northward velocity	16-bit signed integer, low byte first	-300m/s~ +300m/s	Unit is m/s LSB= 0.01m/s
51~52	GNSS vertical velocity	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°	Unit in degrees LSB=0.0003017485"
57~60	GNSS Latitude	32-bit signed integer, low byte first	-90°~ +90°	Unit in degrees LSB=0.0003017485"
61~64	GNSS altitude	32-bit signed integer, low byte first	-500m~ +10000m	Unit is meter LSB= 0.01m
65~66	UTC time/year	16-bit unsigned integer, low byte first	0~65536	Unit is year LSB = 1 year
67	UTC Time/Month	8-bit unsigned integer	1~12	Unit is month LSB = January
68	UTC time/day	8-bit unsigned integer	1~31	Unit is day LSB = 1 day
69	UTC time/hour	8-bit unsigned integer	0~23	Unit in hours LSB = 1 hour
70	UTC time/minute	8-bit unsigned integer	0~59	Unit in minutes LSB = 1 point
71	UTC time/second	8-bit unsigned integer	0~59	Unit in seconds LSB = 1 second
72	UTC time/millisecond	8-bit unsigned integer	0~999	Unit is milliseconds LSB = 10 milliseconds
73	GPS_Collection	8-bit unsigned integer		The unit is a grain

Byte Serial Number	Signal name	Information encoding	Scope	Description
				LSB＝1 MSB＝255
74	BD_Collection	8-bit unsigned integer		The unit is a grain LSB＝1
75	GLONASS _Collection	8-bit unsigned integer		The unit is a grain LSB＝1
76	GPS_Located_Stars	8-bit unsigned integer		The unit is a grain LSB＝1
77	BD_position_stars	8-bit unsigned integer		The unit is a grain LSB＝1
78	GLONASS _Number of positioned stars	8-bit unsigned integer		The unit is a grain LSB＝1
79	Fault status word 1	8-bit character type		D0: X-axis gyro failure D1: Y-axis gyro failure D2: Z-axis gyro failure D3: gyro light source failure D4: X-axis plus meter failure D5: Y-axis plus meter fault D6: Z-axis plus meter fault D7: add meter acquisition circuit fault =0, normal; =1, fault.
80	Fault status word 2	8-bit character type		D0: Power module 1 failure D1: Power module 2 failure D2: Power module 3 failure D3: IMU module communication failure D4: Alignment failure D5: Data Rationalization Failure D6~7: Reservation (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~D0, x is the value of bits D7~D5
84	Checksum	8-bit unsigned number		The cumulative sum of all previous bytes (except frame header) is taken as the lower 8 bits