INERTIAL NAVIGATION SYSTEM V1.0

BS-FN301-M-D6EC

Product characteristics

- Gyro Range: ±500°/s
- Acceleration range:±20g
- Heading accuracy: ≤0.06 °
- Pitach & roll accuracy: ≤0.005 °

Field of application

- UAV Navigation
  Flight navigation
- Robot Navigation
  Vehicle navigation
- AUV Navigation
  ROV navigation

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Number

Classified Make public

Phases

BS-FN301-M-D6EC Technical Specification

Countersig

Compilation

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Approval

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Unit	Department	Name	Date

Catalog

1 Overview

BS-FN301-M-D6EC is a high-precision integrated navigation system. It contains three self-developed 98 fiber optic gyroscopes, three quartz accelerometers, high-precision sampling circuit, navigation computer circuit, GNSS module and power circuit. And high-precision position and navigation in a complex environment are realized through multi-sensor fusion and an integrated navigation algorithm. The product has high reliability and strong environmental adaptability. The products can be widely used in intelligent driving, unmanned aerial vehicle, surveying and mapping, marine compass, stable platform, underwater vehicle, roadheader, mining machinery and other fields.

2 How it works

2.1 Basic composition

The basic components of the BS-FN301-M-D6EC integrated navigation system are shown in Table 1.

Table1 Add requirements for technical indicators

Serial number	**Name of the part**	**Quantity**	**Remark**
1	fiber optic gyroscope	Three	
2	High-precision quartz accelerometer	Three	
3	Power conversion circuit	1 piece	
4	Navigation computer circuit	1 piece	
5	High-precision addition sampling circuit	1 piece	
6	GPS/BD module	1	Optional
7	External GPS/BD antenna	1 set	Default line length 2m

2.2 How it works

The basic principle block diagram of BS-FN301-M-D6EC integrated navigation system is shown in Figure 1.

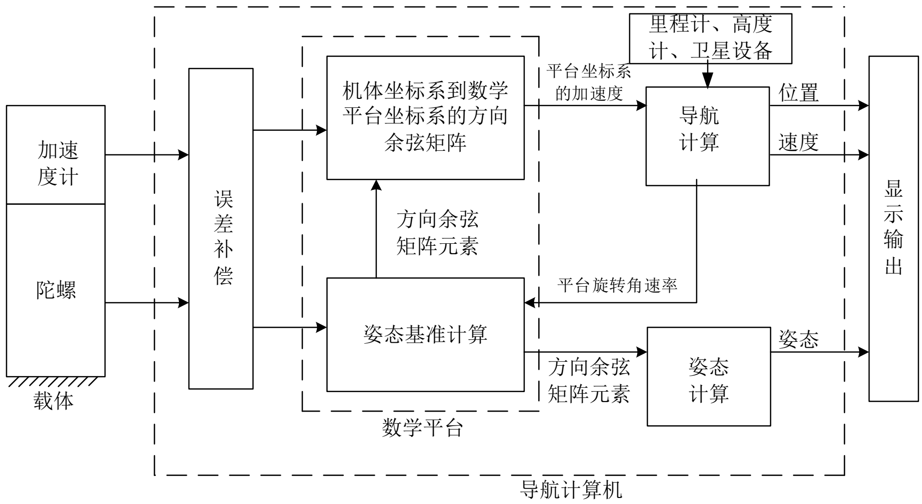

Figure1 System block diagram

The integrated navigation system directly connects gyroscope, accelerometer, odometer and satellite equipment to the carrier. The gyroscope and the accelerometer respectively sense the angular velocity vector of the carrier coordinate system relative to the inertial coordinate system $\boldsymbol{\omega}_{ib}^{b}$ And the specific force vector in the carrier coordinate system $\boldsymbol{f}_{ib}^{b}$ 。The navigation computer is a physical carrier to complete data collection and navigation calculation. It uses the angular velocity of the carrier measured by the gyroscope to calculate the attitude matrix, extracts the attitude and heading information of the carrier from the elements of the attitude matrix, and uses the attitude matrix to transform the output of the accelerometer from the carrier coordinate system to the navigation coordinate system, and then calculates the navigation information such as velocity and position. The position and velocity information obtained from outside (provided by odometer, altimeter and satellite equipment) is used to update the integrated navigation through Kalman filter to provide more accurate real-time position, velocity and attitude information.

3 Main functions

Main functions of the integrated navigation system are as follows:

1) The initial alignment function is completed by using the output of the inertial device, and the shaking base alignment can be carried out;
2) The GPS information received from outside can be used to complete the integrated navigation function and output information such as angle, speed and position;
3) After the satellite signal is lost, the navigation calculation can be continued by using the output of the inertial device and the input of the speedometer;

4) It can output high performance and high sampling rate gyro raw output and add raw data for stable platform control;

5) The program and configuration parameters can be upgraded online through the serial port.

4 Technical indicators

The technical index is only an example, and the specific index requirements refer to the signed Technical Agreement, Technical Requirements, Technical Contract and other documents.

4.1 Technical specifications of inertial devices

The specific parameters of the inertial instrument used in the integrated navigation system are shown in Table 2 ~ Table 3, and the test method of the gyroscope refers to GJB2426 A-2015.

Table2Gyro technology

Project		Indicators	Remark
Gyro channel	Measuring range	-500°/s ～+500°/s	
	Resolution	≤0.01°/h	
	Zero-bias residual	-0.02°/h ～+0.02°/h	
	Random walk	≤0.0015°/√h	
	Zero bias stability at room temperature	≤0.01°/h (1 σ,10s)	10 seconds smoothing, 1H test result
	Zero bias stability at full temperature	≤0.015°/h (1 σ,10s)	10 seconds smoothing, 1H test result
	Normal-temperature zero-bias repeatability	≤0.01°/h (1 σ)	Statistics of 6 test data
	Zero-bias repeatability at full temperature	≤0.015°/h (1 σ)	Take 2 zero-bias data at full temperature, high temperature, low temperature and normal temperature respectively
	Scale factor nonlinearity	≤5ppm	Full temperature and constant temperature
	Scale factor repeatability	≤5ppm (1 σ)	Full temperature and constant temperature
	Gyro start time	≤5s	

	Gyro bandwidth	>300Hz	Design assurance, batch testing
	Installation error residual of three-axis gyroscope	≤10"	

Table3Add table technical indicators

Project		Indicators	Remark
Acceleration channel	Measuring range	-20g ～ +20g	Design and selection guarantee
	Zero bias stability at full temperature	≤50ug（1 σ）	10 seconds smoothing, 1H test result
	Zero-bias repeatability at full temperature	≤80ug（1 σ）	Take 2 zero-bias data at full temperature, high temperature, low temperature and normal temperature respectively
	Add up the starting time	≤5s	
	Triaxial addition installation error residual	≤10"	

4.2 Technical index of navigation solution

The alignment and navigation indexes of the integrated navigation system are shown in Table 4 ~ Table 6, and the test methods of relevant technical indexes are shown in GJB5418-2005.

Table4Alignment accuracy

Project		Indicators	Remark
Alignment accuracy	North seeking time	≤5min	Generally, the standard is 3min or 5min.
	Heading Angle Alignment Repeatability	≤0.06°/cosL	1σ
	Pitch Alignment Repeatability	≤0.005°	1σ
	Roll Angle Alignment Repeatability	≤0.005°	1σ
	North-seeking mode	Optional	It can realize swaying base alignment, GPS auxiliary alignment during travel, odometer auxiliary alignment during travel and main inertial navigation transfer alignment.

Table5Integrated navigation accuracy (satellite effective)

Project		Indicators	Remark
Integrated navigation	Accuracy of course angle measurement	≤0.03°	1σ
	Accuracy of pitch angle	≤0.02°	1σ

accuracy	measurement		
	Roll angle measurement accuracy	≤0.02°	1σ
	Speed accuracy	≤0.03m/s	Satellite is valid
	Position accuracy	≤1.5m	Satellite Point Positioning, CEP
	Position accuracy	≤2cm+1ppm	Satellite RTK Fixed Solution, CEP

Table6Inertial navigation accuracy (invalid satellite)

Project		Indicators	Remark
Inertial navigation accuracy	Accuracy of course angle maintenance	≤0.03°/h	
	Pitch Angle Holding Accuracy	≤0.02°/h	
	Accuracy of roll angle maintenance	≤0.02°/h	
	Pure inertial horizontal positioning accuracy	≤ 0.5 nautical miles/H (5h)	50% CEP without external information assistance (GJB729-89)
	Position positioning accuracy of odometer integrated navigation	≤ 0.1% (mileage more than 3 km)	

4.3 GPS/BD performance index

Support network RTK service and support dual antennas.

Table7GPS/BD nominal accuracy

Project	**Indicators**	**Remark**
GPS Cold Start Time	≤25s	Typical value
GPS Hot Start Time	≤5s	Typical value
GNSS RTK Initialization Time	≤5s	Typical value
Receiving satellite signal frequency point	GPS L1CA/L5	
	BDS B1I/B2a	
	GLONASS L1	
	GALILEO E1/E5a	
	QZSS L1/L5	
Number of channels	198	
Measurement accuracy of single antenna track angle	0.3°	Maneuvering conditions are required
Horizontal positioning accuracy of single point	1.5m	RMS

Positioning accuracy of single point elevation	3.0m	RMS
Horizontal positioning accuracy of RTK floating-point solution	10mm+1ppm	RMS
Height positioning accuracy of RTK floating point solution	20mm+1ppm	RMS
Speed accuracy	0.03m/s	RMS
PPS time accuracy	20ns	RMS
GPS data update rate	1Hz、5Hz	

4.4 Technical index of environmental adaptability

Relevant requirements for environmental adaptability shall be implemented in accordance with GJB150A.

Table8Environmental adaptability

Project	Indicators	Remark
Operating temperature	-40℃～+70℃	
Storage temperature	-45℃～+70℃	
Vibration adaptability	20Hz～2000Hz；0.04g2/Hz	
Impact adaptability	20g, 11 ms, half sine	

Other environmental adaptability tests can be carried out with the whole machine, such as low air pressure, strong wind adaptability, constant humidity and heat, temperature-humidity-altitude, acceleration, solar radiation, rain, temperature shock, mold, salt fog, sand and dust, electromagnetic compatibility, etc.

4.5 Routine item inspection technical index

It mainly includes appearance, interface and so on.

Table9Technical indicators of conventional items

Project	Indicators	Remark
Appearance color	Golden	
Identification	Mark the forward direction and identify the basic information of product	See mechanical interface for details.
Overall	178mm*178mm*134.5mm	Tolerance ± 1 mm

dimensions		
Installation dimensions	162mm*162mm（4*Φ6.5）	Tolerance ± 0.2 mm
Weight	≤6kg	
Supply voltage	18V～36V(DC)	
Steady-state power consumption	≤20W	
Peak power consumption	≤50W	
Communication interface form	CAN	500Kbps, external wheel speed information, sending navigation information
Communication interface form	RS422	Baud rate and output frequency can be customized
Communication interface form	Network interface	

5 External interface

5.1 Mechanical interface

The inertial measurement unit and GNSS receiver adopt an integrated design scheme and are integrated in the integrated navigation system. The system outline is shown in Figure 2.

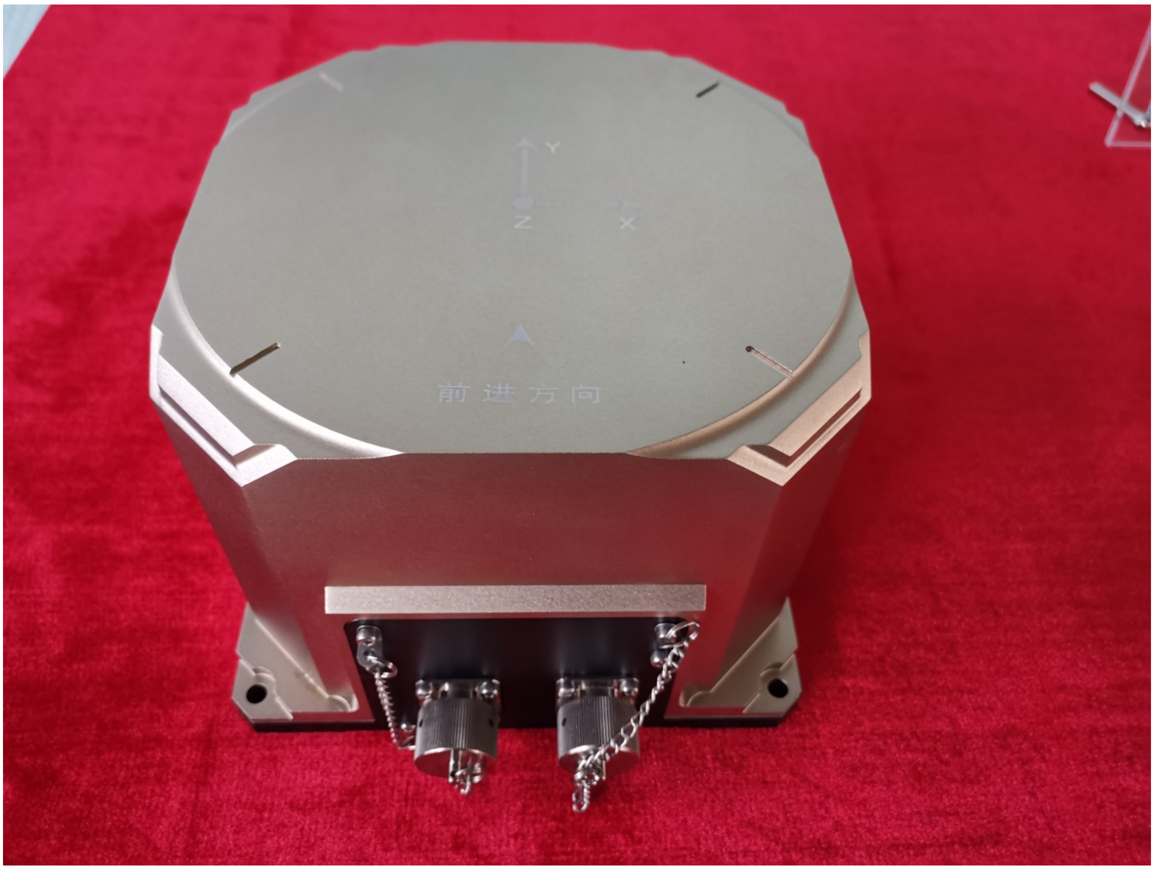

Figure2Outline dimension block diagram

5.2 Electrical interface

The system has four external connectors: one is the communication interface, one is the power supply interface, and two are the SMA interfaces of GPS. The details are as follows:

Table10Definition of power input interface

	表2 Name	表3 Definition of point number	表4 Remark
1	Input 28 V supply positive	1	+
2	Input 28 V supply negative	2	−
The connector model is			

Table11Test interface definition

	表6 Name	表7 Definition of point number	表8 Remark
1	Interface with customer T +	5	Communicate with customers
2	Interface with customer T-	4	
3	Interfacing with customers R +	2	
4	Interface with Customer R-	1	
Connector model: Y50X5-1013Z10K			

The SMA socket is female.

5.3 Communication interface

Current products and communication protocols can be customized according to customer requirements.At present, the general interface protocol of our company is shown in the following table.

Table12Universal Byte Protocol

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
1	Frame header	short	2	0-1	None	0x55, 0xAA (0x55 is the low byte)
2	Frame sequence number	Unsigned int	4	2-5	0.01 seconds	Plus 1 every 0.01 second
3	System status	Unsigned char	1	6	None	The current state of the inertial navigation system, 0x00 is the power ready state, 0x01 is the power ready state, 0x02 is the alignment state, 0x03 is the pure inertial navigation

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
						state, 0x04 is the GPS integrated navigation state, and 0x05 is the odometer integrated navigation state.
4	System fault information	Unsigned short int	2	7-8	None	Generally, 0 is fault and 1 is normal. See Table 3 for the definition.
5	X-gyro raw incremental information	float	4	9-12	LSB/°/s	The initial moment is the original output of the gyroscope and accelerometer. The initial value of the parameter shall be burned at the initial moment. Except for the change of polarity, the result of the data shall not be affected.
6	Y gyro raw incremental information	float	4	13-16	LSB/°/s	
7	Z gyro raw incremental information	float	4	17-20	LSB/°/s	
8	X adds the original delta information	float	4	21-24	LSB/m/s2	
9	Y adds the original incremental information	float	4	25-28	LSB/m/s2	
10	Z adds the original delta information	float	4	29-32	LSB/m/s2	
11	X-axis compensation clearance delta information	float	4	33-36	°/s	The specific content is determined according to the format of parameter programming. When the temperature compensation parameter is programmed, the data is the data after temperature compensation. When the tool error compensation is completed, the data is Wibbx, Wibby, Wibbz, Fibbx, Fibby, Fibbz.
12	Y-axis compensation back delta information	float	4	37-40	°/s	
13	Z-axis compensation back delta	float	4	41-44	°/s	

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
	information					
14	Linear velocity increment information after X-axis compensation	float	4	45-48	m/s/s	
15	Linear velocity increment information after Y-axis compensation	float	4	49-52	m/s/s	
16	Linear velocity increment information after Z-axis compensation	float	4	53-56	m/s/s	
17	Heading angle	float	4	57-60	°	Clockwise is positive
18	Pitch Angle	float	4	61-64	°	Head up is positive
19	Roll Angle	float	4	65-68	°	Right leaning is positive
20	Eastbound speed	Short int	2	69-70	m/s	1LSB=0.01m/s
21	Northbound speed	Short int	2	71-72	m/s	1LSB=0.01m/s
22	Celestial speed	Short int	2	73-74	m/s	1LSB=0.01m/s
23	Longitude	int	4	75-78	°	WGS84 coordinate system, positive east longitude, negative west longitude, 1LSB = 180/ (232-1) + 70 °
24	Latitude	int	4	79-82	°	WGS84 coordinate system, north latitude is positive, south latitude is negative,

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
						1LSB = 90/ (232-1) °
25	Height	Float	4	83-86	m	Elevation in WGS84 coordinate system
26	Eastward speed of satellite (main inertial navigation system)	Short int	2	87-88	m/s	1LSB=0.01m/s
27	Satellite (main inertial navigation) northbound velocity	Short int	2	89-90	m/s	1LSB=0.01m/s
28	Atellite (main inertial navigation) celestial velocity	Short int	2	91-92	m/s	1LSB=0.01m/s
29	Satellite (Master Inertial Navigation) Longitude	int	4	93-96	°	WGS84 coordinate system, positive east longitude, negative west longitude, 1LSB = 180/ (232-1) + 70 °
30	Satellite (main inertial navigation) latitude	int	4	97-100	°	WGS84 coordinate system, north latitude is positive, south latitude is negative, 1LSB = 90/ (232-1) °
31	Satellite (Master Inertial Navigation) Altitude	Float	4	101-104	m	Elevation in WGS84 coordinate system
32	Gyro temperature	Short int	2	105-106	°	1LSB=0.01℃
33	Add gauge temperature	Short int	2	107-108	°	1LSB=0.01℃
34	X Gyro (2)	float	4	109-112	LSB/°/s	

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
35	Y Gyro (2)	float	4	113-116	LSB/°/s	
36	Z Gyro (2)	float	4	117-120	LSB/°/s	
37	X plus (2)	float	4	121-124	LSB/m/s2	
38	Y plus (2)	float	4	125-128	LSB/m/s2	
39	Z Plus (2)	float	4	129-132	LSB/m/s2	
40	GPS pps	Unsigned int	4	133-136		
41	GPS quality	Unsigned char	1	137	None	GPS Quality Indicator 0 = Positioning is unavailable or invalid 1 = single point positioning 2 = pseudorange differential 4 = RTK fixed solution 5 = RTK Float Solution 6 = GNSS/INS integrated navigation 7 = Fixed Position Convert to characters when displayed
42	Wheel Speed-Left Front	Float	4	138-141	ˆ	Odometer accumulation and data
43	Wheel Speed-Right Front	Float	4	142-145	ˆ	Odometer incremental data
44	Wheel speed-left rear	Float	4	146-149	ˆ	Odometer accumulation and data
45	Wheel Speed-Right Rear	Float	4	150-153	ˆ	Odometer incremental data
46	Reserved	float	4	154-157		The default is 0
47	Reserved	float	4	158-161		The default is 0

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
48	Reserved	Float	4	162-165		The default is 0
49	Data checksum	Unsigned char	1	166	None	Accumulate the sum of all bytes except the frame header, take the lowest byte of the accumulated sum, and the overflow of high bits will not be counted
Note:						

6 System parameter configuration

6.1 Configuration of the installation coordinate system

At present, the "X, Y, Z" coordinates marked on the product are installed on the carrier in the right front direction by default, which can be changed through the configuration command.

6.2 Lever arm coordinate configuration for satellite antenna installation

At present, under the customer's load system, the parameters of the outer lever arm of the satellite antenna can be configured.

6.3 Configuration of Installation Error Angle between Carrier and Inertial Navigation

At present, under the customer's load system, the installation error angle between the main inertial navigation and the sub-inertial navigation can be configured. Pay attention to the rotation sequence.

6.4 Odometer parameter configuration

At present. The odometer parameters are initially determined with the customer before delivery and are estimated in real time. After delivery, it is necessary to calibrate the odometer parameters with the customer's products and burn them into our products.

6.5 Main inertial navigation coordinate configuration

At present, under the customer's carrier system, the coordinates of our inertial navigation in the customer's carrier coordinate system can be configured.