INERTIAL NAVIGATION SYSTEM V1.7

BS-FN150-M-D6EC

Product characteristics

- Gyro Range: ±500°/s
- Acceleration Range: ±20g
- Heading accuracy: ≤0.2°
- Pitch & Roll accuracy : ≤0.05°

Field of application

UAV Navigation
Flight navigation

Robot Navigation
Vehicle navigation

AUV Navigation
ROV navigation

Countersig	Version A Number Classified Make public Phases

BS-FN150-M-D6EC
Technical Specification

Compilation

Proofread

Audit

Bid review

Approval

Countersign page

Unit	Department	Name	Date

Catalog

1 Overview

BS-FN150-M-D6EC is a high-precision integrated navigation system. It is equipped with three self-developed high-precision 40 three-axis integrated fiber optic gyroscopes and three MEMS accelerometers, and achieves high-precision orientation and navigation in complex environments through multi-sensor fusion. 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, photoelectric pod, underwater vehicle, subway and other fields.

2 How it works

2.1 Basic composition

The basic components of the BS-FN150-M-D6EC integrated navigation system are shown in Table 1.

Table1Add requirements for technical indicators

Serial number	**Name of the part**	**Quantity**	**Remark**
1	Model 40 Triaxial Fiber Optic Gyroscope	1	
2	High-precision MEMS single-axis MEMS meter	Three	Optional quartz accelerometer
3	Power conversion circuit	1	
4	Navigation computer circuit	1 piece	

2.2 How it works

The basic principle block diagram of BS-FN150-M-D6EC integrated navigation system is shown in Figure 1.

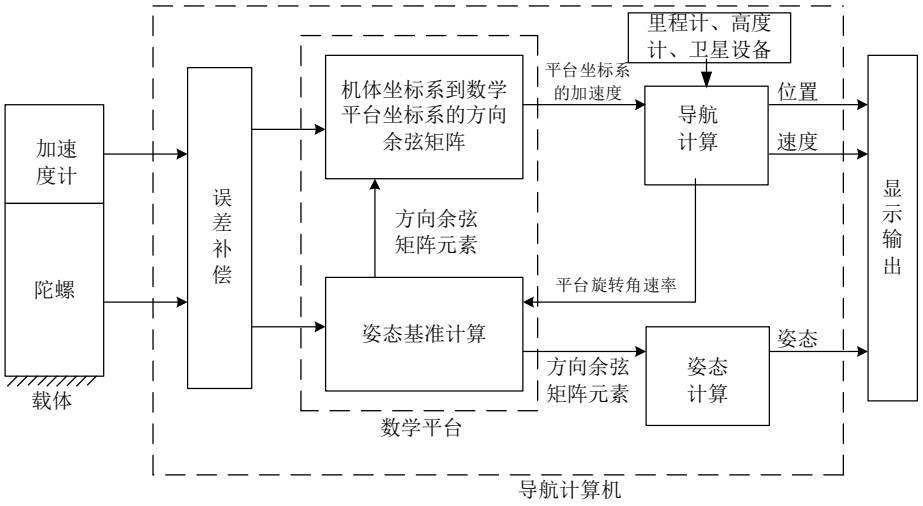

Figure1**System block diagram**

The integrated navigation system is that the gyroscope and accelerometer are directly fixed on 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 combined navigation is updated through a Kalman filter by using external motion information constraints, and more accurate real-time position, velocity and attitude information is provided.

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 and the mooring system alignment can be carried out;
2) Inertial device output and carrier constraint information can be used for navigation calculation to obtain more accurate navigation information such as angle, velocity and position;
3) The program and configuration parameters can be upgraded online through the serial port.

4 Technical indicators

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

Item	Purpose	Indicators	Remark
GYRO	Measuring range	-500°/s ～+500°/s	
	Zero-bias residual	-0.25°/h ～+0.25°/h	
	Random walk	0.05 °/h	
	Zero bias stability at room temperature	≤0.1°/h（1σ）	10 seconds smoothing, 1H test result
	Zero bias stability at full temperature	≤0.15°/h（1σ）	10 seconds smoothing, 1H test result
	Normal-temperature zero-bias repeatability	≤0.1°/h（1σ）	Statistics of 6 test data
	Zero-bias repeatability at full temperature	≤0.15°/h（1σ）	Take 2 zero-bias data at full temperature, high temperature, low temperature and normal temperature respectively
	Scale factor nonlinearity	≤30ppm	Full temperature and constant temperature
	Scale factor repeatability	≤30ppm（1σ）	Full temperature and constant temperature
	Gyro start time	≤5s	
	Gyro bandwidth	300Hz	Design assurance, batch testing
	Installation error residual of three-axis gyroscope	≤80"	

Table3Add table technical indicators

Item	Purpose	Indicators	Remark
ACC	Measuring range	-20g ～ +20g	Design and selection guarantee
	Scale factor nonlinearity	≤300ppm	Design and selection guarantee
	Zero bias stability at full temperature	≤100ug（1σ）	10 seconds smoothing, 1H test result

	Zero-bias repeatability at full temperature	≤100ug（1σ）	Take 2 zero-bias data at full temperature, high temperature, low temperature and normal temperature respectively
	Scale factor repeatability	≤100ppm（1σ）	Design and selection guarantee
	Random walk	≤0.02m/s/h$^{1/2}$	
	Add up the starting time	≤5s	
	Triaxial addition installation error residual	≤80"	

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

Item	Purpose	Indicators	Remark
Alignment accuracy	Static self-north seeking time	≤5min	
	Heading Angle Alignment Repeatability	≤0.2°	1σ
	Pitch Alignment Repeatability	≤0.05°	1σ
	Roll Angle Alignment Repeatability	≤0.05°	1σ
	North-seeking mode	Optional	Shaking base alignment can be achieved

Table6Inertial navigation accuracy

Item	Purpose	Indicators	Remark
Inertial navigation accuracy	Accuracy of course angle maintenance	≤0.15°/h	
	Pitch Angle Holding Accuracy	≤0.05°/h	
	Accuracy of roll angle maintenance	≤0.05°/h	
	Inertial positioning accuracy	≤10m（300s，3km）	CEP, Carrier Constraint
	Inertial positioning accuracy	≤2000m（15min）	Airborne, error peak-to-peak

4.3 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℃～+60℃	
Storage temperature	-45℃～+75℃	
Vibration adaptability	20Hz～2000Hz；0.04g^2/Hz	
Impact adaptability	20g, 11ms, 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.

4.4 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 dimensions	78mm*78mm*80mm	Tolerance ± 1 mm
Installation dimensions	69.5mm*69.5mm（4*Φ4.5）	Tolerance ± 0.2 mm
Weight	≤700g	
Supply voltage	9V～36V(DC)	
Steady-state power consumption	≤9W	
Peak power consumption	≤20W	
Communication interface form	CAN	500Kbps, sending navigation information
Communication interface form	RS422	Send navigation information

5 External interface

5.1 Mechanical interface

The outline of the system is shown in Figure 2.

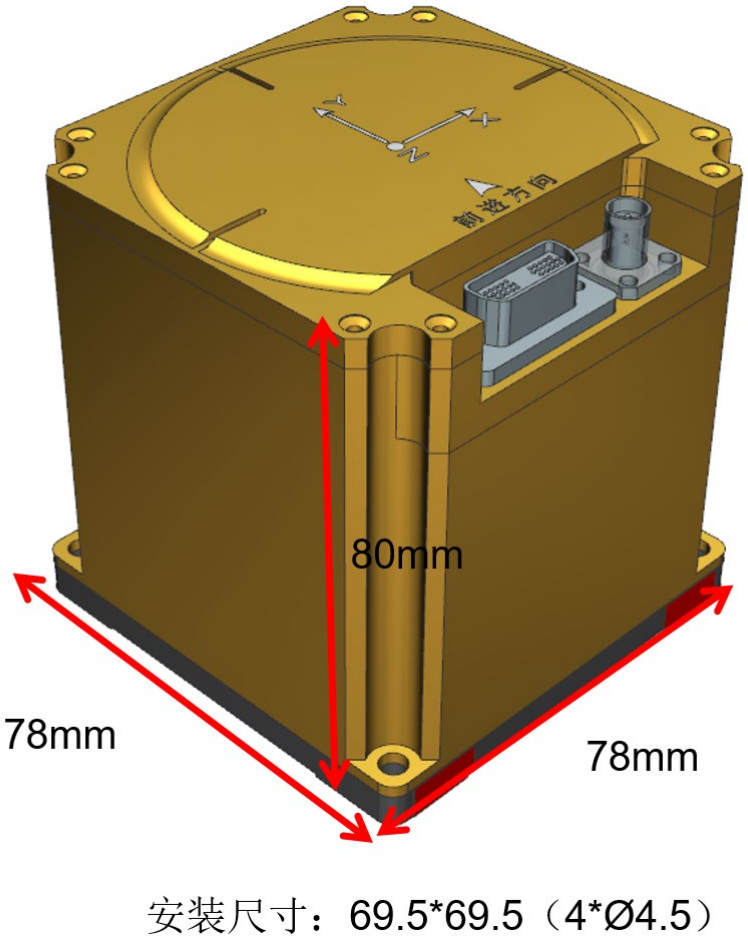

Figure2Outline dimension block diagram

5.2 Electrical interface

Pin definition of communication and power supply interface connector:

Connector model	Terminal number	Network number
J30JM-15ZKSP	7	GND (power ground)
	8	GND (power ground)
	9	CAN-H (CAN High)
	10	CAN-L (CAN Low)
	11	FGND (signal ground)
	14	12 V (supply positive)
	15	12 V (supply positive)
	1	R- (receive north seeking command)

	2	R + (receive north finding command)
	3	T + (send navigation results)
	4	T- (Send navigation results)

10.3 Communication interface

Current products and communication protocols can be customized according to customer requirements. It is also possible to use our general communication protocol, which is as follows:

First, explain the working process of the system: after power-on, the system enters the self-test state, which lasts for about 10 seconds. After the self-test is completed, the system enters the preparation state. In this state, it can receive the north-finding command. After receiving the north-finding command, it can automatically enter the north-finding state, which lasts for 5 minutes. Note that the system cannot be moved in this state. At the end of 5 minutes, the system automatically enters the navigation state, in which the system can move freely. At the same time, it outputs credible information such as angle, velocity and position.

The form of output information of asynchronous serial port RS422 interface is mainly described here. The baud rate is 921,600 bps, the update rate is 200Hz, there is no check, 8 data bits, 1start bit, and no stop bit. See Table 10 for communication protocol.

Table10Communication protocol of RS422 interface navigation equipment output

Serial number	**Data definition**	**Data type**	**Number of bytes**	**Byte sequence number**	**Unit**	**Remark**
1	Frame header	short	2	0-1	None	0 X 55,0 xAA (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, where 0x00 is the power-up ready state, 0x01 is the power-up ready state, 0x02 is the aligning state, and 0x04 is the navigation state

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
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/s^2	
9	Y adds the original incremental information	float	4	25-28	LSB/m/s^2	
10	Z adds the original delta information	float	4	29-32	LSB/m/s^2	
11	X-axis compensation clearance delta information	float	4	33-36	°/s	The specific content is determined according to the format of the parameter programming, and when the temperature compensation parameter is programmed, the data is the data after the temperature compensation; Wibbx, Wibby, Wibbz, Fibbx, Fibby, Fibbz when tool error compensation is complete.
12	Y-axis compensation back delta information	float	4	37-40	°/s	
13	Z-axis compensation back delta information	float	4	41-44	°/s	
14	Linear velocity increment information	float	4	45-48	m/s/s	

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
	after X-axis compensation					
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/ (2^{32} -1) + 70 °
24	Latitude	int	4	79-82	°	WGS84 coordinate system, north latitude is positive, south latitude is negative, 1LSB = 90/ (2^{32} -1) °
25	Height	Float	4	83-86	m	Elevation in WGS84 coordinate system

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
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/ (2 ^{32} -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/ (2 ^{32} -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	Reserved receiving external gyro plus data
35	Y Gyro (2)	float	4	113-116	LSB/°/s	
36	Z Gyro (2)	float	4	117-120	LSB/°/s	

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
37	X plus (2)	float	4	121-124	LSB/m/s^2	
38	Y plus (2)	float	4	125-128	LSB/m/s^2	
39	Z Plus (2)	float	4	129-132	LSB/m/s^2	
40	GPS pps	Unsigned int	4	133-136		GPS PPS count information
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	^	Odometer Data 1
43	Wheel Speed-Right Front	Float	4	142-145	^	Odometer Data 2
44	Wheel speed-left rear	Float	4	146-149	^	Odometer Data 3
45	Wheel Speed-Right Rear	Float	4	150-153	^	Odometer Data 4
46	Reserved	float	4	154-157		The default is 0
47	Reserved	float	4	158-161		The default is 0
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

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
						byte of the accumulated sum, and the overflow of high bits will not be counted
Note:						

。

Table12Navigation interface alignment command description

Serial number	Data definition	Data type	Number of bytes	Byte sequence number	Unit	Remark
1	Frame header	Unsigned char	1	0	None	0x99
1	Frame header	Unsigned char	1	1	None	0x66
2	Frame header	Unsigned char	1	2	None	0x0c
3	Command type	Unsigned char	1	3	None	0 x01: north finding order
4	Longitude	Unsigned int	4	4-7		WGS84 coordinate system, physical value (°) = 70 + 180 * yard value/ (2^{32} -1)
5	Latitude	Unsigned int	4	8-11		WGS84 coordinate system, physical value (°) = 90 * yard value/ (2^{32} -1)
6	Height	Short int	2	12-13		Elevation in WGS84 coordinate system, 1LSB = 0.1 m
7	Checksum	Unsigned char	1	14		Accumulate the sum of all bytes except the frame header, and take the lower eight bits