V 1.1 of MEMS integrated navigation system.

INS200A-E INS

Product characteristics

- 0.2 ° roll & pitch attitude accuracy (GNSS valid)
- 0.1 ° azimuth accuracy (2m antenna baseline)
- 2 °/H & 4 °/H gyroscope bias stability selectable (Allan)
- 30 μg & 60 μg acceleration bias stability optional (Allan)

Field of application

UAV Navigation Robot N n AUV Navigation

Various air carriers flight ... on land vehicle navi OV navigation

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1-General

INS200A-E integrated navigation system has built-in high-performance MEMS gyroscope and accelerometer, which can receive external GNSS data, realize multi-sensor fusion and integrated navigation algorithm, and has short-term inertial navigation capability when GNSS is invalid.

The product has high reliability and strong environmental adaptability. By matching different software, the products can be widely used in the fields of tactical and industrial unmanned aerial vehicles, unmanned vehicles, unmanned ships, aviation guided bombs, intelligent ammunition, rockets, mobile communication, mapping, seeker and stable platform.

The product is divided into low configuration version (INS200A-E-A0) and high configuration version (INS200A-E-B0). The precision and price of the two products are different, which is convenient for users to choose based on specific use conditions.

2. Functions and indicators

2.1 Main functions

The integrated navigation system can use the satellite navigation information received from the outside to carry out integrated navigation, and output the pitch, roll, course, position, speed, time and other information of the carrier; After losing the signal, it outputs the position, velocity and attitude information of inertial solution, and has a certain navigation accuracy maintenance function in a short time. When combined with navigation, it can output the raw information that can be used for post-processing to be processed by the IE post-processing software of NovAtel.

2.2 Performance indicators

The system performance is shown in Table 1.

Table 1 System Performance Requirements

Project		Metrics (RMS)	Remark
Heading accuracy	Dual GNSS	0.1°	2m baseline
	Single GNSS	0.2°	Need to maneuver
	GNSS failure retention accuracy	0.2°/min	INS200A-E-B0
		0.5°/min	INS200A-E-A0
Attitude accuracy	GNSS is valid	0.1°	INS200A-E-B0
		0.2°	INS200A-E-A0
	GNSS failure retention accuracy	0.2°/min	INS200A-E-B0
		0.5°/min	INS200A-E-A0
	V-G mode (GNSS failure time unlimited, no acceleration)	2°	INS200A-E-B0
		4°	INS200A-E-A0

Project		Metrics (RMS)	Remark
Horizontal positioning accuracy	GNSS is valid	1.2m	Single-point L1/L2
		2cm+1ppm	RTK
	GNSS failure (60s)	20m	INS200A-E-B0
		100m	INS200A-E-A0
Horizontal velocity	GNSS is valid	0.1m/s	Single-point L1/L2
Gyroscope	Measuring range	±450°/s	
	Zero-bias stability (Allan variance)	2°/h	INS200A-E-B0
		4°/h	INS200A-E-A0
Accelerometer	Measuring range	±16g	Customizable 200 G
	Zero-bias stability (Allan variance)	30μg	INS200A-E-B0
		60μg	INS200A-E-A0
Communication interface	UART	Route 2	
	PPS	Route 1	Input, LVTTL
	SPI	Route 1	
Electrical characteristics	Voltage	3~3.6VDC	
	Power consumption	≤1.5W	
	Ripple	100 mV	P-P
Structural characteristics	Size	47 mm×44 mm×14mm	
	Weight	≤50g	
Use environment	Operating temperature	-40℃~+70℃	
	Storage temperature	-45℃~+75℃	
	Vibration	20~2000Hz ,	
	Impact	1000g, 0.5ms	
Reliability	MTBF	20000h	
	Life span	> 15 years	
	Continuous working time	>120h	
Note: Unless otherwise specified, the accuracy index refers to RMS.			

3. Working principle

3.1 Product composition

The composition of the product is shown in Figure 1.

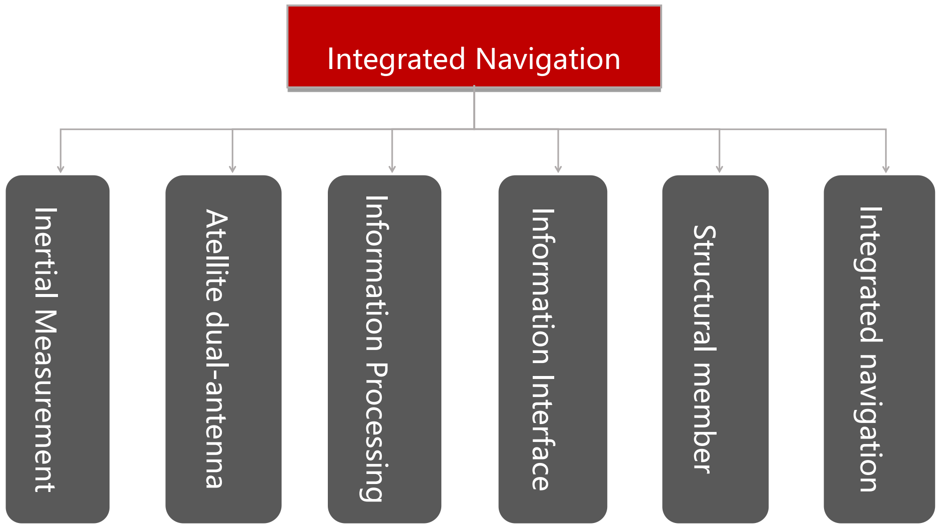

Figure 1 System composition

3.2 Fundamentals

The inertial measurement unit consists of three accelerometers and three gyroscopes and is used for measuring the acceleration and the angular velocity of a carrier and sending the information to the information processing circuit; and the information processing circuit performs navigation settlement by using the acceleration and the angular velocity measured by the inertial measurement unit and simultaneously receives satellite navigation information output by an external GNSS receiver as a reference to perform combined navigation, The navigation error of the inertial navigation is corrected, and the navigation information is output through the information interface circuit.

The basic principle is shown in Figure 2.

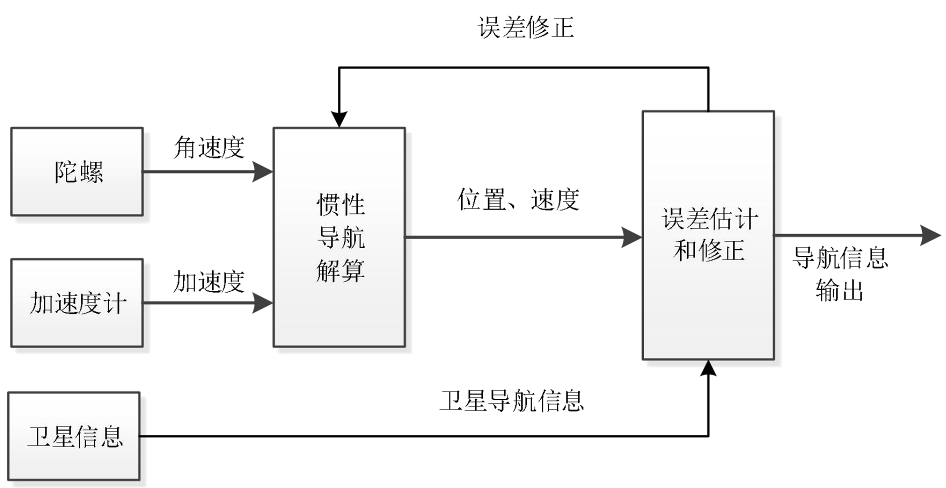

Fig. 2 Schematic diagram of working principle

4.Instructions for use

4.1 overall dimensions

The overall dimensions of the system are: 47mm × 44mm × 14mm (length × width × height), and the overall dimensions of the system are shown in Figure 3. (Note: Mounting holes can be threaded holes for M 2.5 or M 2.2)

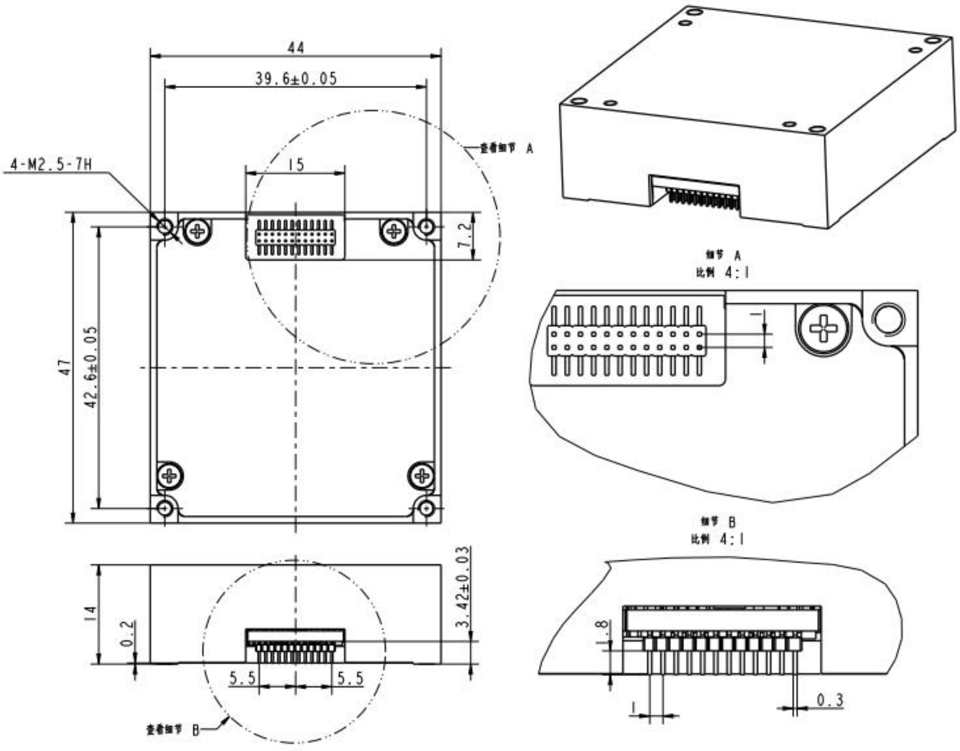

Fig. 3 Outline structure of integrated navigation system

4.2 Electrical interface

The contact sequence of the external connector of the system is shown in the figure below:

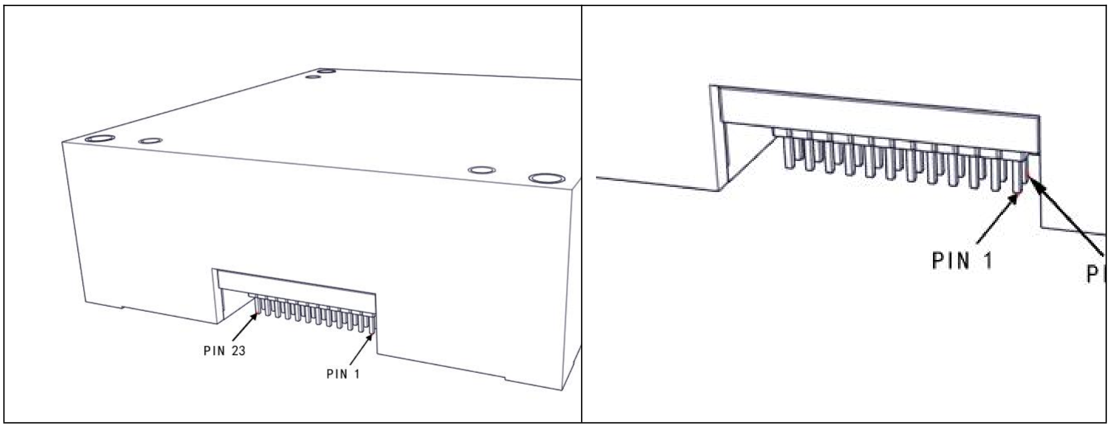

Fig. 4 Schematic diagram of external connector contact sequence of integrated navigation system

The external connector points are defined in Table 2.

Table 2 Connector Point Definition

Pin sequence	Name	Type	Description
10, 11, 12	VDD	Power source	
13, 14, 15	GND	Power source	
7	DIO1	Input/output	PPS input pin, falling edge trigger
9	DIO2	Input/output	General purpose IO, configurable
1	DIO3	Input/output	
2	DIO4	Input/output	
3	SPI-CLK	Input/output	SPI, master slave mode configurable, default to slave mode
4	SPI-MISO	Input/output	
5	SPI-MOSI	Input/output	
6	SPI-/CS	Input/output	
19	UART1-TXD	Output	UART, baud rate is configurable, default is 460800 bps
21	UART1-RXD	Input	
22	UART2-TXD	Output	UART, baud rate is configurable, default is 460800 bps
24	UART2-RXD	Input	
8	RST	Input	Reset
23	VDDRTC	Power source	
Other	NC	Spare	Retained by the manufacturer

4.3 Instructions for use

Workflow of 4.3.1 system

The system has two working modes, integrated navigation mode and inertial navigation mode. Wherein the combined navigation mode is a default working mode after being started. The default operating mode can be changed by command. If the setting is successful, it will return to the "cmd OK" ", otherwise, the cmd error" will be displayed. After the input is completed, type "saveconfig" to save the current configuration, and the current configuration will be automatically called after the next restart. If the command is not input, the configuration saved last time will be restored after the next restart.

The command for setting the combined navigation mode as the default working mode is as follows:

#moddgi

The command to set the inertial navigation mode to the default working mode is:

#modins

4.3.1.1 integrated navigation mode flow

After entering the integrated navigation process, the system automatically enters the coarse alignment state, and the coarse alignment time is 3s; in the coarse alignment state, the system waits for effective satellite navigation information, and the integrated navigation system is required to be static during the coarse alignment; when the satellite navigation information is effective, the system enters the integrated navigation state, otherwise, the system maintains the coarse alignment state; When the system is in the integrated navigation state, the integrated navigation system can move.

4.3.1.2 Inertial Navigation Mode Flow

After entering the inertial navigation process, the system automatically enters the coarse alignment state, the coarse alignment time is 3 s, the system waits for effective satellite navigation information in the coarse alignment state, and the integrated navigation system is required to be static during the coarse alignment; when the satellite navigation information is effective, the system enters the fine alignment state, otherwise, the system automatically enters the fine alignment state after waiting for the 1.5 s; After fine alignment for 1500 s, it will automatically switch to the inertial navigation state. When the system is in the state of fine alignment or inertial navigation, the integrated navigation system can move.

The 4.3.1.3 system is reset

During operation, input the "# reset" command, and the system will perform soft reset and display the startup information again.

4.3.2 system configuration instruction

4.3.2.1 Configuration Scheme and Storage

The integrated navigation system is externally provided with 2 serial ports, and the function distribution and relevant configuration of each serial port are shown in Table 3. (Note: if the development board INS100A-IMU-TEST-V 1.3 provided by our company is used, since it is a previous-generation product, the com number marked on the development board is contrary to the definition in the following table, that is, the COM1 of the development board is COM2 of the product, and COM2 is COM1 of the product)

Table 3 Serial port function distribution of integrated navigation system

String slogan s	Enter the project	Output items	Default
COM1	1. working mode instruction and flow control instruction; 2. COM1 ~ COM2 baud rate, protocol and update rate configuration;	1.inspvasa、bdfpd 、bdfpdb、bdfpdl、gpfpd、INStest(0.2Hz、1Hz、5Hz、10Hz、100Hz... 200Hz, etc.); 2.rawimusb、rawdata、INSpost (200Hz); 3.Configure the prompt message.	460800bps; Output: bdfpdl 1Hz;
COM2	1. working mode instruction and flow control instruction; 2. COM1 ~ COM2	Same as item 1-3 in COM 1	460800bps Output: INSpost

String slogans	Enter the project	Output items	Default
	baud rate, protocol and update rate configuration;		

After the system is powered on and the start prompt information is displayed on the COM1 port, you can input the commands such as COM1 ~ COM2 serial port baud rate configuration, serial port protocol and update rate setting. If each command is output successfully, it will return to the "cmd OK" ", otherwise it will display the cmd error". After the input is completed, type "saveconfig" to save the current configuration. The current configuration will be called automatically after the next restart. If the command is not input, the serial port configuration will be restored to the last saved configuration after the next restart.

4.3.2.2 configuration query

Type the "log loglist" or "log rxstatus" command through the COM1 port to list all the configurations of COM1-COM2, including the following contents:

Serial port number, serial port baud rate, serial port protocol and update rate;

Open state of function module: including zero-speed correction state and smooth processing state, enable when open and disable when closed;

Initial binding longitude and latitude;

Initially binding the included angle between the double-antenna heading and the integrated navigation system heading;

Initial binding antenna mast arm value;

System number and date of manufacture;

Software version number: including pre-processing software version number and navigation software version number;

Operating mode: including integrated navigation (DGI) and pure inertial navigation (INS).

4.3.2.3 baud rate configuration

In this mode, enter the following command to enter the serial port baud rate configuration:

com comX BAUDRATA

Where X is 1 ~ 2 and BAUDRATA is the baud rate in bps.

For example, set the baud rate of the COM1 port to 115200 bps, and input the following command:

com com1 115200

4.3.2.4 protocol and update rate configuration

4.3.2.4.1 protocol and update rate configuration

Configure the output protocol of COM1 ~ COM2 through COM1, and the configuration command is as follows:

log comX LOG ontime updataTime

Where, comX can be the configuration number of com 1 ~ com2; The updataTime represents the update time, which can be a period of 5 (0.2 Hz), 1 (1 Hz), 0.2 (5 Hz), 0.1 (10 Hz), 0.01 (100 Hz), etc., which can be divided by 200 Hz, and the unit is s.

LOG indicates the protocol name, which can be inspvasa, bdfpd, gpfpd, etc.

For example, if you want to configure the COM2 port to output 10Hz bdfpd data, you can input the following command through COM1:

log com2 bdfpd ontime 0.1

If 10Hz inspvasa data needs to be output at COM2 at the same time, the following command can be input through COM1:

log com2 inspvasa ontime 0.1

If you want to shut down a protocol, the configuration command is as follows:

log comX LOG off

Configure the rawdata protocol of COM 1 ~ COM2 ports through COM1, and the configuration commands are as follows:

log comX rawdata onchanged

If you want to close the rawdata protocol of the serial port, the configuration command is as follows:

log comX rawdata off

If you want to close all protocols of the serial port, the configuration command is as follows:

unlogall comX

It should be noted that increasing the update rate or outputting multiple protocols at the same time will increase the amount of data sent by the serial port. Before use, it is necessary to configure the appropriate baud rate, otherwise it may cause data loss. In general, the larger the amount of data, the higher the baud rate required.

4.3.2.4.2 protocol format

The output protocols supported by the product are shown in the following table.

Table 4 Output Data Protocol Description

Serial number	Data protocol name	Type of agreement	Output type	Support interface
1	gpfpd	ASCII	ontime	COM1-COM2
2	bdfpd	ASCII	ontime	COM1-COM2
3	bdfpdb	Binary	ontime	COM1-COM2
4	Bdfpdb1	Binary	ontime	COM1-COM2
5	rawimusb	Binary	onchanged	COM1-COM2
6	inspvasa	ASCII	ontime	COM1-COM2
7	rawdata	Binary	onchanged	COM1-COM2
8	bdfpdl	ASCII	ontime	COM1-COM2

The ASCII type protocol conforms to the NMEA protocol format requirement and comprises the following fields: a statement identifier, a plurality of data fields,ChecksumEnd tag (with carriage return < CR > andLine break< LF >) separated by commas. Take the bdfpd protocol as an example, the format is as follows:

$BDFPD,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*xx<CR><LF>

The rawdata protocol includes rawimusb, rangecmpb, bestvelb, bestposb, headingb, and psrdopb. The contents of rangecmpb, bestvelb, bestposb, headingb and psrdopb protocols are shown in the NovAtel protocol description. The protocol formats of gpfpd, bdfpd, bdfpdbl, inspvasa, bdfpdb, and rawimusb are shown in the following table.

Table 5 gpfpd format

Serial number	Name	Meaning	Data type	Unit
1	$GPFPD	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
7	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
8	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
9	Height	Height of the combined output	Floating-point type	m

Serial number	Name	Meaning	Data type	Unit
10	East speed	Combined output east speed	Floating-point type	m/s
11	North speed	Combined output north speed	Floating-point type	m/s
12	Sky speed	Combined output speed	Floating-point type	m/s
13	Baseline length	Distance between centers of two satellite antenna	Integer	Meters
14	NSV1	Number of satellites for antenna 1	Integer	A
15	NSV2	Number of satellites for antenna 2	Integer	A
16	Satellite status	Satellite status 0: unavailable, 1: available	Integer	—
17	Check code	Check code (value after exclusive or of number between $and *)	Hexadecimal	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 6 bdfpd format

Serial number	Name	Meaning	Data type	Unit
1	$BDFPD	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
7	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
8	Longitude	Combined output longitude -180 ° ~ 1809 °	Floating-point type	Degree
9	Height	Height of the combined output	Floating-point type	m
10	East speed	Combined output east	Floating-po	m/s

Serial number	Name	Meaning	Data type	Unit
		speed	int type	
11	North speed	Combined output north speed	Floating-point type	m/s
12	Sky speed	Combined output speed	Floating-point type	m/s
13	NSV1	Number of satellites for antenna 1	Integer	A
14	NSV2	Number of satellites for antenna 2	Integer	A
15	Positioning type	Postype in bestpos, see Table 12	Integer	—
16	Directional type	Postype in heading, see Table 12	Integer	—
17	Check code	Check code (value after exclusive or of number between $and *)	Hexadecimal	—
18	<CR><LF>	Fix the tail of the package	—	—

Table 7 Format of bdfpdl

Serial number	Name	Meaning	Data type	Unit
1	$BDFPD	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
5	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
6	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
7	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
8	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
9	Height	Height of the combined output	Floating-point type	m
10	East speed	Combined output east speed	Floating-point type	m/s

Serial number	Name	Meaning	Data type	Unit
11	North speed	Combined output north speed	Floating-point type	m/s
12	Sky speed	Combined output speed	Floating-point type	m/s
13	X-axis angular rate	IMU is on the right	Floating-point type	°/s
14	Y-axis angular rate	Before the IMU system	Floating-point type	°/s
15	Z-axis angular rate	Attach the IMU	Floating-point type	°/s
16	X-axis acceleration	IMU is on the right	Floating-point type	m/s2
17	Y-axis acceleration	Before the IMU system	Floating-point type	m/s2
18	Z-axis acceleration	Attach the IMU	Floating-point type	m/s2
19	NSV1	Number of satellites for antenna 1	Integer	A
20	NSV2	Number of satellites for	Integer	A

Serial number	Name	Meaning	Data type	Unit
		antenna 2		
21	Positioning type	Postype in bestpos, see Table 12	Integer	—
22	Directional type	Postype in heading, see Table 12	Integer	—
23	System status word	0 x00: Standby 0 x10: coarse alignment 0 x20: fine alignment 0x30: integrated navigation 0x31: Inertial navigation		
24	Check code	Check code (value after exclusive or of number between $and *)	Hexadecimal	—
25	<CR><LF>	Fix the tail of the package	—	—

Table 8 Format of inspvasa

Serial number	Name	Meaning	Data type	Unit
1	%INSPVASA	Format header	—	—
2	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
3	GPS cycles per second	GPS cycles per second	Floating-point type	s
4	GPSWeek	Current Week Number Since 1980-1-6 (GMT)	Integer	—
5	GPS cycles per second	GPS cycles per second	Floating point number	s
6	Latitude	Combined Output Latitude -90 ° ~ 90 °	Floating-point type	Degree
7	Longitude	Combined output longitude -180 ° ~ 180 °	Floating-point type	Degree
8	Height	Height of the combined output	Floating-point type	m
9	North speed	Combined output north speed	Floating-point type	m/s
10	East speed	Combined output east	Floating-poin	m/s

Serial number	Name	Meaning	Data type	Unit
		speed	t type	
11	Sky speed	Combined output speed	Floating-point type	m/s
12	Roll Angle	Roll angle -180 ° ~ 180 °	Floating-point type	Degree
13	Pitch Angle	Pitch angle -90 ° ~ 90 °	Floating-point type	Degree
14	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	Floating-point type	Degree
15	INS status	See Table 11	—	—
16	Check code	Check code (number between% and * 32-bit CRC check)	Hexadecimal	—
17	<CR><LF>	Fix the tail of the package	—	—

Table 9 bdfpdb protocol description

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0xaa	—	Header
	2		0x44	—	
	3		0x10	—	

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
2	4	Message length	0x40	—	
3	5-8	Week of GNSS	Current Week Number Since 1980-1-6 (GMT)	unsigned int	—
4	9-16	Week second	GPS cycles per second	double	—
5	17-20	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	float	—
6	21-24	Pitch Angle	Pitch angle -90 ° ~ 90 °	float	—
7	25-28	Roll Angle	Roll angle -180 ° ~ 180 °	float	—
8	29-36	Latitude	Combined Output Latitude -90 ° ~ 90 °	double	—
9	37-44	Longitude	Combined output longitude -180 ° ~ 180 °	double	—
10	45-48	Height	Height of the combined output	float	—
11	49-52	East speed	Combined output east speed	float	—
12	53-56	North speed	Combined output north speed	float	—
13	57-60	Sky speed	Combined output speed	float	—
14	61-62	NSV1	Number of satellites for antenna 1	unsigned short	—
15	63-64	NSV2	Number of satellites for antenna 2	unsigned short	—
16	65-66	Positioning type	Postype in bestpos, see Table 13	unsigned short	—
17	67-68	Directional type	The postype in heading is shown in Table 13	unsigned short	—
18	69-72	Checksum	5-68 bytes 4-byte accumulate sum check	—	—

Table 10 Description of raw imusb protocol

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0xaa	—	Header
	2		0x44	—	
	3		0x10	—	
2	4	Message length	0x3c	—	
3	5-8	Week of GNSS	Current Week Number Since 1980-1-6 (GMT)	unsigned int	—
4	9-12	Week second	GPS cycles per second	float	—
5	13-16	Yaw Angle	Yaw 0 ~ 360 degrees, clockwise	float	—
6	17-20	Pitch Angle	Pitch angle -90 ° ~ 90 °	float	—
7	21-24	Roll Angle	Roll angle -180 ° ~ 180 °	float	—
8	25-32	Latitude	Combined Output Latitude -90 ° ~ 90 °	double	—
9	33-40	Longitude	Combined output longitude -180 ° ~ 180 °	double	—
10	41-44	Height	Height of the combined output	float	—
11	45-48	East speed	Combined output east speed	float	—
12	49-52	North speed	Combined output north speed	float	—
13	53-56	Sky speed	Combined output speed	float	—
14	57-58	NSV1	Number of satellites for antenna 1	unsigned short	—
15	59-60	NSV2	Number of satellites for antenna 2	unsigned short	—
16	61-62	Positioning type	Postype in bestpos, see Table 13	unsigned short	—
17	63-64	Directional type	The postype in heading is shown in Table 13	unsigned short	—
18	65-68	Checksum	5-64 bytes 4-byte accumulate sum check	—	—

Table 11 Description of raw imusb protocol

Serial number	Number of bytes	Definition	Meaning	Data type	Remark
1	1	Frame header	0xaa	—	Header
	2		0x44	—	
	3		0x13	—	
2	4	Message length	0x28	—	
3	5-6	Message ID number	0x145	—	—
4	7-8	Week of GNSS	—	unsigned short	—
5	9-12	Week second	ms	unsigned int	—
6	13-16	Week of GNSS	—	unsigned int	
7	17-24	Week second	s	double	
8	25-28	IMU status word	See Table 14	unsigned int	
9	29-32	Z-direction accelerometer output (upper)	m/s2	int	200*200*2-31
10	33-36	-Y accelerometer output (rear)	m/s2	int	200*200*2-31
11	37-40	X-direction accelerometer output (right)	m/s2	int	200*200*2-31
12	41-44	Z-direction gyroscope output (upper)	°/s	int	200*720*2-31
13	45-48	-Y-gyro output (rear)	°/s	int	200*720*2-31
14	49-52	X-direction gyroscope output (right)	°/s	int	200*720*2-31
15	53-56	Checksum	1-52 byte 32-bit CRC check	unsigned int	—

Table 12 INS Status Description

INS status word	Status word description
INS_INACTIVE	IMU logs are present, but the alignment routine has not started; INS is inactive.
INS_ALIGNING	INS is in alignment mode.

INS_SOLUTION_GOOD	The INS filter is in navigation mode and the INS solution is good.

Table 13 postype description

Type numeric value	Type definition	Type description
0	NONE	No solution
1	FIXEDPOS	Position has been fixed by the FIX POSITION command
2	FIXEDHEIGHT	Position has been fixed by the FIX HEIGHT/AUTO command
8	DOPPLER_VELOCITY	Velocity computed using instantaneous Doppler
16	SINGLE	Single point position
17	PSRDIFF	Pseudorange differential solution
18	WAAS	Solution calculated using corrections from an WAAS
19	PROPAGATED	Propagated by a Kalman filter without new observations
20	OMNISTAR	OmniSTAR VBS position
32	L1_FLOAT	Floating L1 ambiguity solution
33	IONOFREE_FLOAT	Floating ionospheric-free ambiguity solution
34	NARROW_FLOAT	Floating narrow-lane ambiguity solution
48	L1_INT	Integer L1 ambiguity solution
50	NARROW_INT	Integer narrow-lane ambiguity solution
64	OMNISTAR_HP	OmniSTAR HP position
65	OMNISTAR_XP	OmniSTAR XP or G2 position
68	PPP_CONVERGING	Converging PPP solution
69	PPP	Converged PPP solution
70	OPERATIONAL	Solution accuracy is within UAL operational limit
71	WARNING	Solution accuracy is outside UAL operational limit but within warning limit
72	OUT_OF_BOUNDS	Solution accuracy is outside UAL limits

Table 14 IMU Status Word Description

Bit sequence number	Type description	
0	X Gyro status	1: normal, 0: fault
1	Y Gyro status	
2	Z gyro status	

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Bit sequence number	Type description	
3	Spare	
4	X Accelerometer Status	1: normal, 0: fault
5	Y Accelerometer Status	
6	Z Accelerometer Status	
7-31	Spare	—

4.3.2.4.332 bit CRC check calculation method

The 32-bit CRC check calculation method can be obtained by using the following C language function.

```
#define CRC32_POLYNOMIAL 0xEDB88320L
/* --------------------------------------------------------------------------
Calculate a CRC value to be used by CRC calculation functions.
-------------------------------------------------------------------------- */
unsigned long CRC32Value(int i) {
     int j;
     unsigned long ulCRC;
     ulCRC = i;
     for ( j = 8 ; j > 0; j-- ) {
          if ( ulCRC & 1 )
               ulCRC = ( ulCRC >> 1 ) ^ CRC32_POLYNOMIAL;
          else
               ulCRC >>= 1;
     }
     return ulCRC;
}

/* --------------------------------------------------------------------------
Calculates the CRC-32 of a block of data all at once
ulCount - Number of bytes in the data block
ucBuffer - Data block
-------------------------------------------------------------------------- */
unsigned long CalculateBlockCRC32( unsigned long ulCount, unsigned char
*ucBuffer ) {
     unsigned long ulTemp1;
     unsigned long ulTemp2;
     unsigned long ulCRC = 0;
     while ( ulCount-- != 0 ) {
          ulTemp1 = ( ulCRC >> 8 ) & 0x00FFFFFFL;
          ulTemp2 = CRC32Value( ((int) ulCRC ^ *ucBuffer++ ) & 0xFF );
          ulCRC = ulTemp1 ^ ulTemp2;
     }
     return( ulCRC );
}
```

4.3.2.5 initial value configuration

Initial longitude and latitude configuration, configuration instructions are:

initialpos LONGITUDE LATILUDE

Where LONGITUDE and LATITUDE are configured local longitude and latitude values in degrees.

4.3.2.6 function module configuration

Functional modules with open configuration mainly include zero velocity correction and output position smoothing.

4.3.2.6.1 "Zero Velocity Trim" Configuration

The zero-velocity correction function mainly means that the integrated navigation system detects the sensitive information, and if the integrated navigation system is judged to be zero-velocity, the corresponding correction is carried out.

In the integrated navigation process of this product, the "zero velocity correction" is enabled by default. If the satellite information is invalid for a long time in the integrated navigation state, and the user wants to get the pure inertial navigation information, it is recommended to close the zero velocity correction mode.

The zero speed correction configuration instructions are as follows:

inszupt switch

The switch value is either disable or enable, where disable turns the feature off and enable turns the feature on.

4.3.2.6.2 Position Output Smoothing configuration

In order to get more smooth position information, the navigation software adds the function of position output smoothing, which makes the position noise smaller after smoothing.

In the integrated navigation process of this product, "Position Output Smoothing" is off by default. In order to facilitate the user's selection, this function can be configured. The configuration instructions are as follows:

possmoothswitch

The switch value is either disable or enable, where disable turns the feature off and enable turns the feature on.

4.3.2.7 carrier type configuration

According to different carriers installed in the integrated navigation system, the carrier type configuration is required, and different algorithm processing is carried out in the integrated navigation system according to different carrier types.

The configuration instructions are as follows:

carrier vehicle/ship/air

They are vehicle-mounted, ship-mounted and airborne in turn.

After the configuration is completed, you need to enter the save command "saveconfig", and then hard start or enter the "# reset" command. The carrier type configuration will be valid after startup. The integrated navigation system does not support current configuration and current use during use, and must be restarted.

After the carrier type is configured as the vehicle-mounted type, the integrated navigation system is required to be installed and fixed on the vehicle, and the heading of the integrated navigation system is consistent with the head direction of the vehicle, with an error of not more than 10 degrees.

4.3.2.8 GNSS antenna mast arm configuration

According to the relative installation relationship between the antenna and the integrated navigation system, it is necessary to configure the antenna rod arm. The lever arm value between the integrated navigation system and the antenna must be accurate to millimeter (mm) during measurement, especially during RTK operation. Any lever arm measurement error will directly enter the position error output by the integrated navigation system. During installation and use, the integrated navigation system should be as close as possible to the main antenna, especially in the horizontal position. The command is required to be completed before or during the alignment of the integrated navigation system on the stationary base and before the alignment of the integrated navigation system on the moving base. Once the configuration is complete, it needs to be saved via "saveconfig".

The configurations include a master antenna rod arm configuration and a slave antenna rod arm configuration.

The main antenna configuration instructions are as follows:

setimutoantoffsetarmX armY armZ

The slave antenna configuration instructions are as follows:

setimutoantoffset2armX armY armZ

Where armX, armY and armZ are the configured lever arm values in meters, representing the components of the vector from the integrated navigation system to the antenna phase center in the integrated navigation system carrier coordinate system, and the integrated navigation system carrier coordinate system is selected as the right front top (XYZ). For the example in Figure 5, armX and armY should be negative, and armZ should be positive.

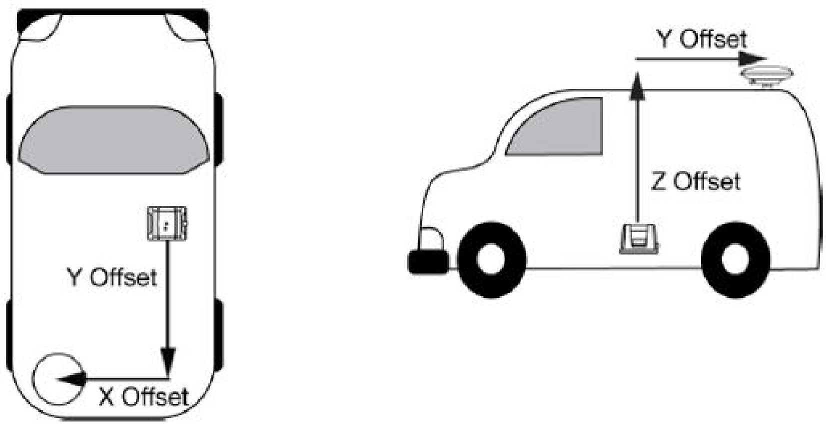

Figure 5 Schematic diagram of antenna rod arm

4.3.2.9 Output Lever Arm Settings

The default value for the product output lever arm configuration is [0,0,0] (upper right front), which outputs the position and speed values at the integrated navigation system. If the position and speed of the user's test point need to be output, the output lever arm should be set according to the relative installation relationship between the test point and the integrated navigation system.

The lever arm value from the configuration of integrated navigation system to the test point must be accurate to millimeters (mm) during measurement, especially during RTK operation, any lever arm measurement error will directly enter the position error output by the integrated navigation system. The command is required to be completed before or during the alignment of the integrated navigation system on the stationary base and before the alignment of the integrated navigation system on the moving base. Once the configuration is complete, it needs to be saved via "saveconfig".

The output lever arm configuration commands are as follows:

setimutosensoroffsetarmX armY armZ

Where armX, armY, and armZ are the configured lever arm values, in meters, representing the components of the vector from the integrated navigation system to the test point in the integrated navigation system carrier coordinate system, and the integrated navigation system carrier coordinate system is selected as the right front top (XYZ). For the example in Figure 6, armY and armZ should be positive.

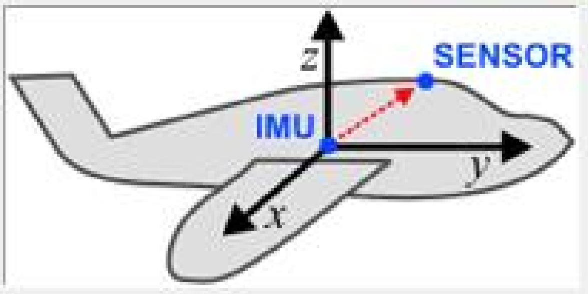

Fig. 6 Schematic diagram of output lever arm

Setting of mounting angle of 4.3.2.9

The attitude and heading information output by the product are Euler angles of the product coordinate system relative to the geographic coordinate system. The angle installation relationship between the product and the carrier coordinate system is the installation angle, and the default configuration value is [0,0,0] (pitch, heading, roll), that is, the product coordinate system and the installation carrier coordinate system coincide. If there is an installation angle when the product is installed on the carrier, and the Euler angle of the carrier coordinate system relative to the geographic coordinate system needs to be output by the product, the installation angle should be set according to the relative installation relationship between the product and the carrier.

Mounting angle configuration instructions are as follows:

vehiclebodyrotationangleX angleZ angleY

Where angleX, angleZ and angleY are the configured installation angle values, in degrees, representing the angles from the carrier coordinate system to the integrated navigation system coordinate system, in the order of pitch, course and roll.

4.3.2.10 forced rotation inertial navigation

When the integrated navigation system is in the integrated navigation state, the integrated navigation system can receive the forced rotation inertial navigation instruction and switch to the inertial navigation state. In this state, the integrated navigation system still receives the satellite navigation information for protocol transmission, but does not use the satellite navigation information to participate in the integrated navigation calculation. After receiving the effective forced rotation inertial navigation command, the integrated navigation system feeds back the "cmd OK" "through the COM1 port.

Forced-turn inertial navigation commands are as follows:

#moddgitoins

4.3.2.11 GNSS information input interface configuration

The integrated navigation system uses COM2 to receive satellite navigation information by default, and COM1 can also be configured as the input interface of satellite navigation information. When COM1 is set as the satellite navigation information input interface, COM2 is automatically changed to the configuration information input interface.

The instructions for configuring COM1 as the satellite navigation information input interface are as follows:

$SETCONFIGFPGA

The instructions for configuring COM2 as the satellite navigation information input interface are as follows:

$SETCONFIGUART2

4.3.2.12 Configuration Input Interface Configuration

The integrated navigation system uses COM1 to receive configuration command information by default, and COM2 can also be configured as the input interface of configuration command information. When COM2 is set as the configuration command information input interface, COM1 is automatically changed to the satellite navigation information input interface.

The commands for configuring COM1 as the configuration command information input interface are as follows:

$SETCONFIGUART2

The commands for configuring COM2 as the configuration command information input interface are as follows:

$SETCONFIGFPGA

Trigger mode configuration of 4.3.2.13 time synchronization signal

Note: This function applies to the navigation firmware version 2.00 and the firmware version after it.

By default, the integrated navigation system uses the time synchronization signal of the falling edge to trigger. The trigger type is determined by querying the status of the "nTriggerFlag" in the configuration command " $GPINF". If it is equal to 0, it represents the falling edge trigger; if it is equal to 1, it represents the rising edge trigger.

Configure a falling edge trigger with the following command:

$GPFALLEDGE

Configure a rising edge trigger with the following command:

$GPRISEDGE

4.3.3 system maintenance

4.3.3.1 firmware upgrade

When a firmware upgrade is required, proceed as follows:

Make sure that COM1 port is the configuration interface before starting;

Connect the power line and communication line, connect the COM1 port to the computer, and set the COM1 port according to the baud rate setting value of the COM1 port;

After sending the " $GPUPD" command, change the COM1 baud rate to the 256000 bps;

The serial port tool interface displays the start prompt information, and the interface displays "30 …" 10 9 8 7 6 5 4 3 2 Before 1, send ":" (small colon, cancel the option of sending a new line) to the serial port, and the interface displays the updata flash information;

Select the firmware (generally *.bin2 file) to be upgraded through the serial port tool and send it;

After the sending is completed, the program automatically reloads and starts, enters the start prompt information, and starts normally;

The firmware upgrade is complete.

4.3.3.2 parameter upload

In general, the user does not need to upload the calibration parameters, and the configuration has been completed before leaving the factory. Under special circumstances, if the user is required to upload and maintain the parameters, the following steps shall be followed:

After the system completes the startup prompt information normally, you can query the corresponding system number through the "log bdlist"/ "log rxstatus";

Send the "# modbd" command to the integrated navigation system through the COM1 port, and upload the "*.txt" calibration parameter file through the serial port after the "cmd OK" "is returned;

After the interface returns to the calibration parameter information, send the "# saveconfig"/ "saveconfig" command to save the parameters, and then reset the system by soft and hard reset to work normally.

4.3.4 SPI Interface Instruction

During the operation of the integrated navigation system, the real-time IMU data and navigation data are loaded into the output register, and the data can be accessed through the SPI port.

Description of 4.3.4.1 data

The order of IMU data output is front, left, top, 3 gyros (g_x , g_y , g_z) and 3 accelerometers (a_x , a_y , a_z) is defined as shown in the figure below, and the direction of the arrow is positive.

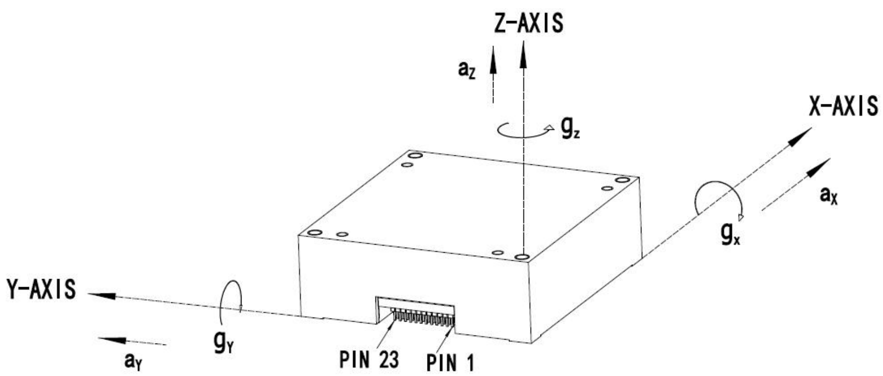

Figure 7 IMU Coordinate Definition Diagram

The definition of navigation data output is the same as that of serial port data.

4.3.4.2 SPI read and write data

IMU data and navigation data are loaded into the output register in real time, and the data can be accessed through the SPI port. The SPI port is typically connected to a compatible port on an embedded processor, as shown in the following figure. Four SPI signals support synchronous serial data transfer. In the factory default configuration, the DIO2 pin provides a data-ready signal. This pin goes high when new data is available in the output data register.

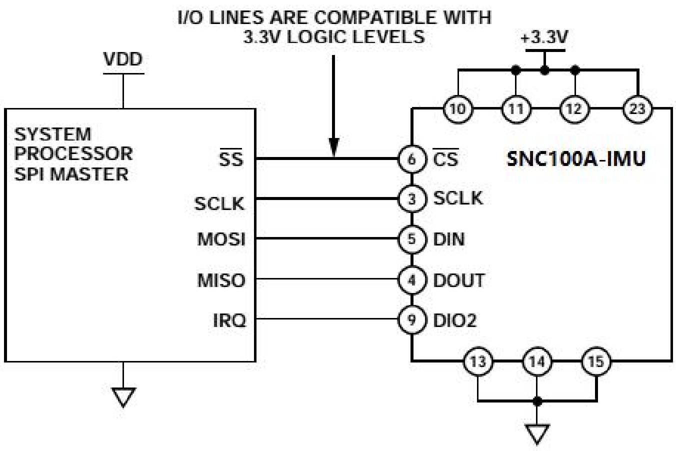

Fig. 8 Connection diagram

4.3.4.3 Generic Host Processor SPI Settings

The generic host processor SPI settings are shown in the following table.

Table 15. Generic Host Processor SPI Settings

Processor settings	Explain
Host	The integrated navigation system is used as a slave
SCLK ≤ 15 MHz	Maximum serial clock ratio
SPI Mode 3	CPOL = 1 (polar), CPHA = 1 (phase)
MSB first mode	Bit Order
16-bit mode	Shift register/data length

4.3.4.4 SPI communication

If the previous command is a read request, the SPI port supports full-duplex communication, and the external processor can read DOUT and write DIN at the same time, as shown in the following figure.

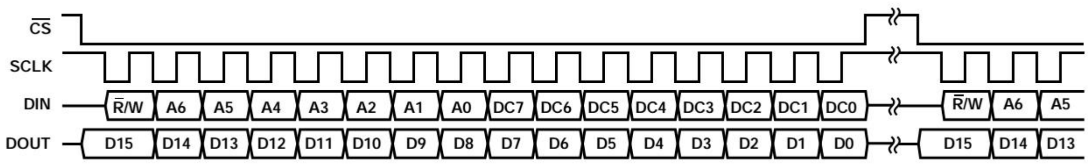

Figure 9 SPI Read/Write Timing Diagram

The 4.3.4.5 reads data

The integrated navigation system automatically starts and activates page 0 for data register access. After accessing any other page, write 0x00 to the PAGE _ ID register (DIN = 0x8000) to activate Page 0 in preparation for subsequent data accesses. A single register read requires two 16-bit SPI cycles. In the first cycle, a read of the contents of a register is requested using the bit assignment function in the following figure; in the second cycle, the register contents are output on DOUT. The first bit of the DIN command is 0, followed by the high or low address of the register. The last eight bits are don't care, but the SPI requires a full 16 SCLKs to receive the request. The following figure shows two consecutive register reads, one with DIN = 0x1A00 requesting the contents of the Z _ GYRO _ OUT register, and the other with DIN = 0x1800 requesting the contents of the Z _ GYRO _ LOW register.

Figure 10. Sample SPI Read Operation

4.3.4.6 User Register Memory Map (N/A = Not Applicable)

The user register memory map is shown in the following table.

Table 16 User Register Memory Map

Name	R/W	PAGE_ID	Address	Default	Register description
TEMP_OUT	R	0x00	0x0E	N/A	Temperature
X_GYRO_LOW	R	0x00	0x10	N/A	X-axis gyroscope output, low word
X_GYRO_OUT	R	0x00	0x12	N/A	X-axis gyroscope output, high word
Y_GYRO_LOW	R	0x00	0x14	N/A	Y-axis gyroscope output, low word
Y_GYRO_OUT	R	0x00	0x16	N/A	Y-axis gyroscope output, high word
Z_GYRO_LOW	R	0x00	0x18	N/A	Z-axis gyroscope output, low word
Z_GYRO_OUT	R	0x00	0x1A	N/A	Z-axis gyroscope output, high word
X_ACCL_LOW	R	0x00	0x1C	N/A	X-axis accelerometer output, low word
X_ACCL_OUT	R	0x00	0x1E	N/A	X-axis accelerometer output, high word
Y_ACCL_LOW	R	0x00	0x20	N/A	Y-axis accelerometer output, low word
Y_ACCL_OUT	R	0x00	0x22	N/A	Y-axis accelerometer output, high word
Z_ACCL_LOW	R	0x00	0x24	N/A	Z-axis accelerometer output, low word
Z_ACCL_OUT	R	0x00	0x26	N/A	Z-axis accelerometer output, high word
Reserved	N/A	0x00	0x28-0x5E	N/A	Reserved
Yaw	R	0x00	0x60	N/A	Yaw 0 ~ 360 degrees, clockwise

Name	R/W	PAGE_ID	Address	Default	Register description
Pitch	R	0x00	0x62	N/A	Pitch angle -90 ° ~ 90 °
Roll	R	0x00	0x64	N/A	Roll angle -180 ° ~ 180 °
Latitude_LOW	R	0x00	0x66	N/A	Combined output latitude -90 ° ~ 90 °, low word
Latitude_HIGH	R	0x00	0x68	N/A	Combined output latitude -90 ° ~ 90 °, high order word
Longitude_LOW	R	0x00	0x6A	N/A	Combined output longitude -180 ° ~ 180 °, low word
Longitude_HIGH	R	0x00	0x6C	N/A	Combined output longitude -180 ° ~ 180 °, high order word
Height	R	0x00	0x6E	N/A	Height of the combined output
East_velocity	R	0x00	0x70	N/A	Combined output east speed
North_velocity	R	0x00	0x72	N/A	Combined output north speed
Up_velocity	R	0x00	0x74	N/A	Combined output speed
Work_status	R	0x00	0x76	N/A	Integrated navigation system working state word 0 x00: Standby 0 x10: coarse alignment 0 x20: fine alignment 0 x30: Navigation
PROD_ID	R	0x00	0x7E	102	Product identification (102) output

4.3.4.7 transformation formula

Current temperature = 25 + TEMP _ OUT * 0.00565.

X-axis gyro value = 0.02 * X _ GYRO _ OUT

Y-axis gyro value = 0.02 * Y _ GYRO _ OUT

Z-axis gyro value = 0.02 * Z _ GYRO _ OUT

X-axis accelerometer value = (long) (X _ ACCL _ OUT * 65536 + X _ ACCL _ LOW) * 0.00001220703125 * 0.001

Y-axis accelerometer value = (long) (Y _ ACCL _ OUT * 65536 + Y _ ACCL _ LOW) * 0.00001220703125 * 0.001

Z-axis accelerometer value = (long) (Z _ ACCL _ OUT * 65536 + Z _ ACCL _ LOW) * 0.00001220703125 * 0.001

Yaw = (unsigned short) Yaw * 0.01

Pitch = (short) pitch * 0.01

Roll angle = (short) roll * 0.01

Latitude = (long) (Latitude _ HIGH * 65536 + Latitude _ LOW) * 0.0000001

Longitude = (long) (Longitude _ HIGH * 65536 + Longitude _ LOW) * 0.0000001

Height = (short) height * 0.1

East speed = (short) East _ velocity * 0.01.

North Speed = (short) North _ velocity * 0.01.

Sky velocity = (short) Up _ velocity * 0.01

4.3.5 Transfer Alignment Function Description

The integrated navigation system can upload the general firmware of transfer alignment, support the working mode of transfer alignment + integrated navigation/inertial navigation, and be applied in the fields of aviation guided bombs, smart munitions, rockets, etc. When it works in the integrated navigation state, it needs to send GNSS positioning information to the integrated navigation system through COM2.

4.3.5.1 workflow

The working mode flow is shown in the figure below.

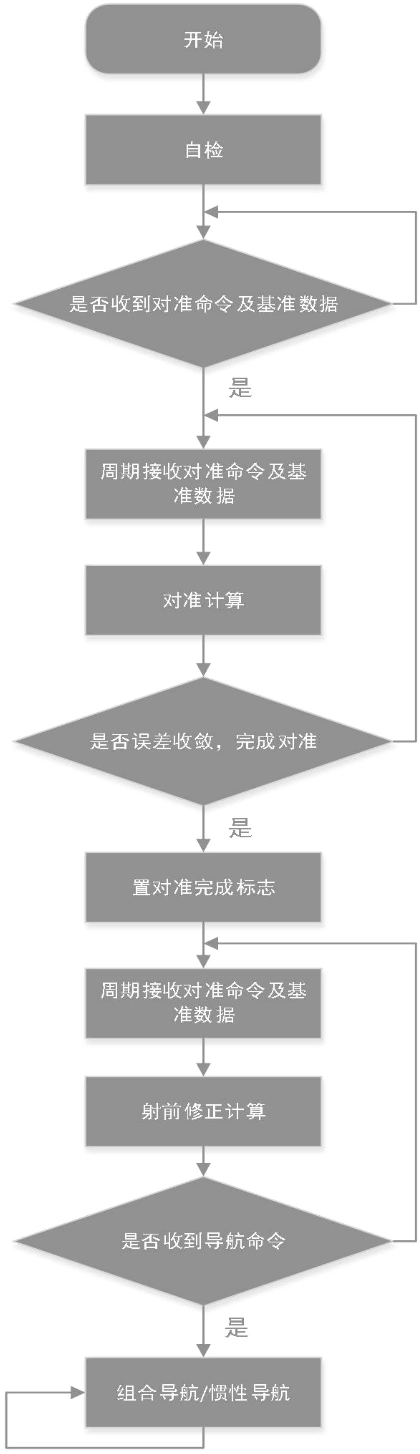

Fig. 11 Flow of Transfer Alignment Mode

4.3.5.2 communication protocol

Communication interface: COM 1;

Baud rate: 115 200 bps;

Byte format: 8 data bits, 1stop bit, no parity bit;

Frame format: low byte first, high byte last;

Frequency: from the flight control system to the integrated navigation system, 10 Hz in the alignment and pre-launch correction stage, and no timing in other stages; Integrated navigation system to flight control, 100Hz.

Table 17 Protocol format from flight control to integrated navigation system

Agreement	Byte sequence number	Data	Data type	Coefficient	Remark
Protocol header	0	0x55	—	—	—
	1	0xaa	—	—	—
Protocol body	2	Command word	—	—	0 X11: Align command 0 x33: Navigation command Rest: No command
	3 4	Heading angle	unsigned short	0.01°	0 ° ~ 360 °, clockwise is positive
	5 6	Pitch Angle	short	0.01°	-90 ° ~ + 90 ° is positive
	7 8	Roll Angle	short	0.01°	-180 ° ~ + 180 ° right tilt is positive
	9 10 11 12	Latitude	int	0.0000001°	The north latitude is positive
	13 14 15 16	Longitude	int	0.0000001°	East longitude is positive
	17 18 19 20	Height	int	0.01m	—
	21 22	North speed	short	0.01m/s	—
	23 24	Sky speed	short	0.01m/s	—
	25 26	East speed	short	0.01m/s	—
	27 28	Frame count	unsigned short	—	—
	29-33	Spare	—	—	—
	34	Checksum	—	—	Accumulate and sum 2 to 33 bytes, take the low byte

End of agreement	35	0x7e	—	—	—
	36	0x7e	—	—	—

Table 18 Format of integrated navigation system to flight control protocol

Agreement	Byte sequence number	Data	Data type	Coefficient	Remark
Protocol header	0	0x55	—	—	—
	1	0xaa	—	—	—
Protocol body	2	Frame count	unsigned short	—	—
	3				
	4	Inertial navigation status	—	—	0 x00: Standby 0 x20: alignment 0 x25: Good alignment 0 x30: Navigation
	5	Heading angle	unsigned short	0.01°	0 ° ~ 360 °, clockwise is positive
	6				
	7	Pitch Angle	short	0.01°	-90 ° ~ + 90 ° is positive
	8				
	9	Roll Angle	short	0.01°	-180 ° ~ + 180 ° right tilt is positive
	10				
	11	Latitude	int	0.0000001°	The north latitude is positive
	12				
	13				
	14				
	15	Longitude	int	0.0000001°	East longitude is positive
	16				
	17				
	18				
	19	Height	int	0.01m	—
	20				
	21				
	22				
	23	North speed	short	0.01m/s	—
	24				
	25	Sky speed	short	0.01m/s	—
	26				
	27	East speed	short	0.01m/s	—
	28				
	29	Angular velocity	float	—	°/s

Agreement	Byte sequence number	Data	Data type	Coefficient	Remark
	30 31 32	in Y direction (front)			
	33 34 35 36	Angular velocity in Z direction (upper)	float	—	°/s
	37 38 39 40	Angular velocity in X direction (right)	float	—	°/s
	41 42 43 44	Y-direction acceleration (front)	float	—	m/s2
	45 46 47 48	Z-direction acceleration (upper)	float	—	m/s2
	49 50 51 52	X-direction acceleration (right)	float	—	m/s2
	53 54 55 56	Wei Dao latitude	int	0.0000001°	The north latitude is positive
	57 58 59 60	Wei Dao longitude	int	0.0000001°	East longitude is positive
	61 62 63 64	Height of guard guide	int	0.01m	—
	65 66	Wei Dao Beisu	short	0.01m/s	—
	67 68	Wei Dao Tian Su	short	0.01m/s	—

Agreement	Byte sequence number	Data	Data type	Coefficient	Remark
	69	Wei Dao Dongsu	short	0.01m/s	—
	70				
	71	PDOP	char	0.1	—
	72	Guidance location status	—	—	'A': Valid 'V': Invalid
	73-79	Spare	—	—	—
	80	Checksum	—	—	Accumulate and sum 2 to 79 bytes, take the low byte
End of agreement	81	0x7e	—	—	—
	82	0x7e	—	—	—

4.4 Coordinate System Definition

The inertial coordinate system is defined as right, front, up, (X, Y, Z), and the direction of the arrow is positive. The coordinate system is defined as shown in the following figure.

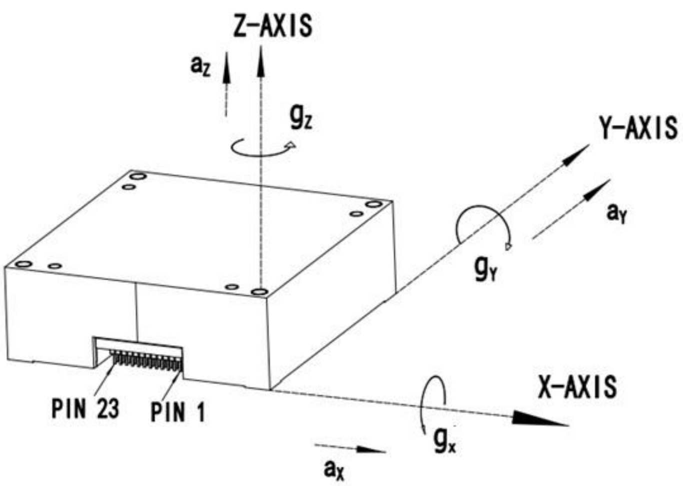

Figure 12 Inertial Navigation Coordinate System Definition

5. Precautions

The main considerations are as follows:

A) The power-on and power-off time interval of the integrated navigation system shall not be less than 30 s, otherwise it is easy to cause damage to the inertial devices;

B) shall be handled with care during handling, installation and use to avoid collision, falling and impact;

The output and baud rate configuration of the C) satellite board shall be as described in the appendix.

6. Appendix

Input configuration of the satellite receiver of the 6.1

The integrated navigation system receives the external satellite navigation information through the COM1 or COM2 port. The output configuration protocol of the external satellite receiver is as follows (the baud rate of the output interface of the external satellite receiver shall be consistent with the setting of the satellite navigation information input interface).

Nova tel-like card:

log comX bestposb ontime 0.2

log comX headingb onchanged/ontime 0.2

log comX bestvelb ontime 0.2

log comX psrdopb ontime 1

Log comX timeb ontime 0.2 (Note: Not required)

Log comX rangecmpb ontime 1 (Note: for post-processing, this command is invalid without the original data board)

saveconfig

General purpose board:

log comX gprmc ontime 0.2

log comX gpgga ontime 0.2

log comX gpgsa ontime 1

log comX gphdt onchanged

saveconfig

7. Update records

Serial number	Version	Change the date	Before the change	After the change	Reason for the change	Changed by
1	V1.00	20200331			New establishment	CHB
2	V1.01	20200402		Add Transfer Alignment Protocol		CHB
3	V1.02	20200416		Change the gpzda input period to 0.2 second	Perfect	CHB

4	V1.03	20200423		The 1、 determines the communication baud rate of the bomb mode as the 115200 bps 2、 to modify the configuration of health guidance	Perfect	CHB
5	V1.04	20200527		Add protocol checksum description	Perfect	CHB
6	V1.05	20200804		Error modifying rawimusb protocol	Perfect	CHB
7	V1.06	20201124		Added description of PPS trigger mode	Perfect	CHB
8	V1.07	20210202		Add the precision description of the low-profile product	Perfect	CHB
9	V1.08	20220402		Add time synchronization signal configuration, update bdfpdb protocol	Perfect	INS
10	V1.09	20221121		Update of bdfpdb protocol message length	Perfect	INS
11	V1.10	20230403		Add bdfpdb1 protocol message	Perfect	INS

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