1.General Description

The BS-IL622-M-D6EC contains a high-precision GNSS module and a factory calibrated IMU, so that it could continuously provide high-precision information on position, velocity, and attitude at high frequency. Even in challenging conditions such as urban canyons, shaded areas, and tunnels, The BS-IL622-M-D6EC will also keep available and self-evaluated reliability by empowered with several algorithms such as multi-source kalman filter.

Product Features：

- Support full-system multi-frequency points of BDS, GPS, GLONASS, Galileo and QZSS, and support the Beidou-3 satellite system
- IMUs have calibrated in factory
- Adaptive static/dynamic alignment
- Configurable universal vehicle motion information (such as ODM) interface
- Adaptive compensation for system installation errors and ODM scale errors
- The horizontal position accuracy can be within 0.2%×D with GNSS outage①.

Figure 1 External view of the BS-IL622-M-D6EC INS

①:Typical

1.1. Main functions

The BS-IL622-M-D6EC contains a high-precision GNSS module and a factory calibrated IMU, so that it could continuously provide high-precision information on position, velocity, and attitude at high frequency. Even in challenging conditions such as urban canyons, shaded areas, and tunnels, The BS-IL622-M-D6EC will also keep available

and self-evaluated reliability by empowered with several algorithms such as multi-source kalman filter.

1.2. Performance

The system performance is shown in Table 1.

Parameters		Typical①	Description
Start Time	GNSS cold start	<25 s	
	GNSS RTK initialization time	<5 s	
	Alignment time of integrated navigation	<60 s	Dual antennas in an open sky, including cold start.
Satellite signal tracking	Frequency point	BDS B1I/B2I/B3I GPS L1/L2/L5 GLONASS L1/L2 GALILEO E1/E5a/E5b	
Heading accuracy	GNSS effective	0.1 °	Dual - antenna with a 2m baseline; single - antenna requires dynamic alignment
	Keep accuracy	0.15 °/min	GNSS failure
Attitude accuracy	GNSS effective	0.1 °	RTK/Single point with dual frequency
	Keep accuracy	0.1 °	GNSS outage 5 minutes, with ODM
Horizontal positioning accuracy	GNSS effective	1.2 m	Single point with dual frequency
		1 cm + 1 ppm	RTK
	Keep accuracy	0.2% × D	With odometer, 60 km/h, within 120 s
Horizontal velocity accuracy	GNSS effective	0.03 m/s	
Time service accuracy	GNSS effective	20 ns	
Gyroscope	Range	±500 °/s	
	Bias instability	2 °/h	Allan variance
	Scale factor nonlinear	200 ppm	
Accelerometer	Range	±8 g	
	Bias instability	0.02 mg	Allan variance
	Scale factor nonlinear	200 ppm	±1 g
Output Frequency	GNSS result	10 Hz	Position/ Speed/ Heading/ Original data information

Parameters		Typical①	Description
	IMU Original data	200 Hz	
	INS result	200 Hz	
Communication interface	RS-422	1 Chanel	
	RS-232	2 Chanels	1 for INS、1 for GNSS
	PPS	1 Chanel	
	Event	1 Chanel	
	CAN	2 Chanels	Data protocol is customized
Electrical characteristics	Voltage	9 ~ 36 VDC	
	Power consumption	≤ 2W	
Mechanical characteristics	Size	60 × 60 × 15 mm	Excluding the dimensions of connectors
		< 75 × 60 × 15 mm	Including the dimensions of connectors
	Weight	≤ 90 g	
Environment characteristics	Working Temperature	-40 ℃ ~ +85 ℃	
	Storage Temperature	-55 ℃ ~ +95 ℃	
	Vibration	6.06 g 20 ~ 2000 Hz	
	Shocking	40 g 11 ms	

Note：

① Indicators without statistical methods are RMS statistics

② "D" can represent any length unit. For example, in the expression "0.2%*D": if D is 2 km, the error will be 0.002 km; if D is 2000 meters, the error will be 2 meters.

③ The statement that "the measurement accuracy may be significantly reduced by 5 to 10 times compared to a system equipped with an odometer" only applies to the "Keep accuracy of Horizontal positioning". In other words, the "Keep accuracy of heading and attitude" remains the same as accuracy with odometer, and all accuracy related to GNSS is also same.

2.Hardware

2.1. Mechanical dimensions

System size:60(L)×60(W)×15(H) mm(excluding mounting holes and connectors), as shown in Figure 2.

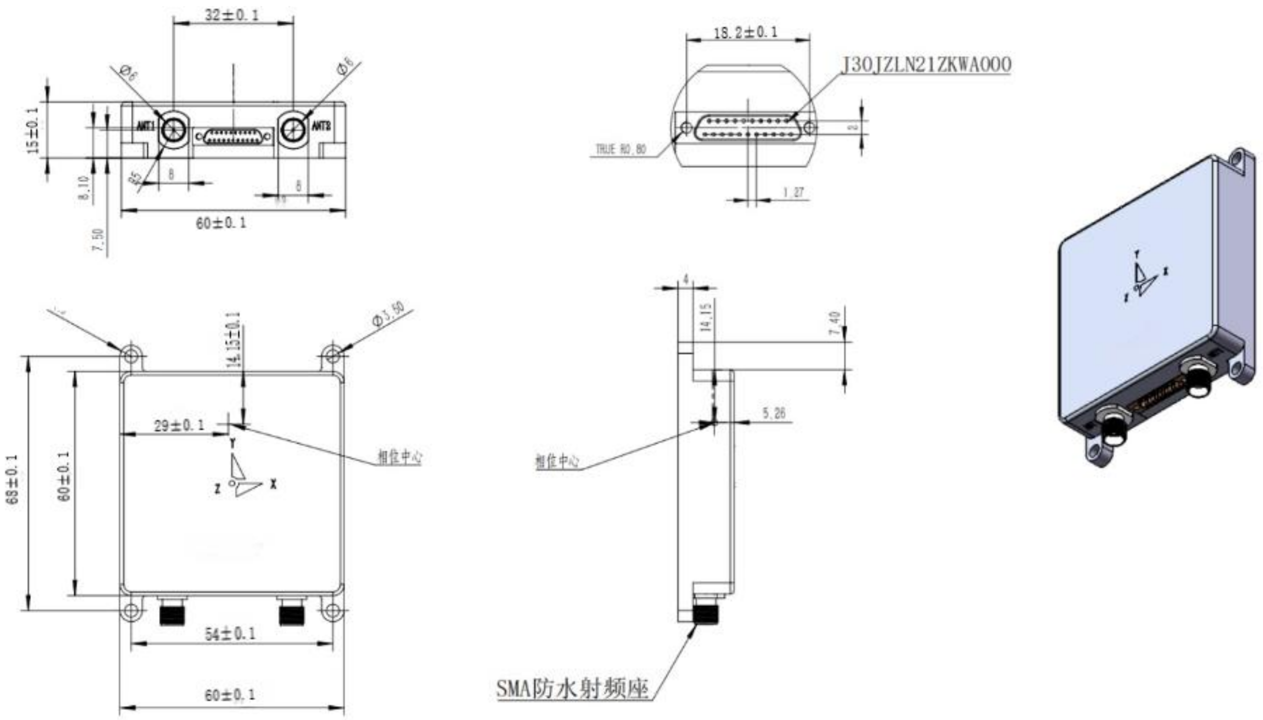


Figure 2 Mechanical dimensions

2.2. Electrical Interface

The BS-IL622-M-D6EC has three connectors. There are two GNSS RF connectors, the left one is for primary antenna(ANT1), and the right one is for secondary antenna(ANT2), there is a main connector for power and communication, which is J30JZLN21ZKWA000. The pin definitions of main connector are descripted as follows.

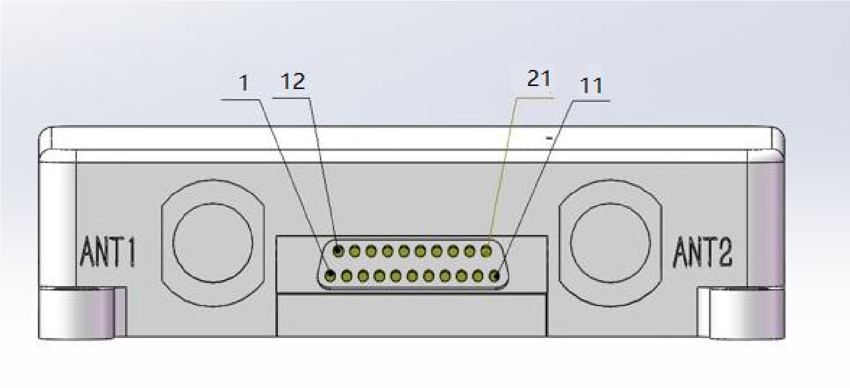


Figure 3 J30JZLN21ZKWA000 Communication Interface

Table 2 Pin definitions

Pin No.	Lable	Type	Description
1	24V_GND	Power ground	Power supply
2			
12	24V	Power supply	
13			
5	COM1_RX	RS-232	COM1
6	COM1_TX		
7	GND		
8	COM2_RX+	RS-422	COM2
9	COM2_RX-		
10	COM2_TX+		
11	COM2_TX-		
19	COM1_GNSS_RX	RS-232	GNSS_COM1
20	COM1_GNSS_TX		
21	GND		
3	CAN1_H	CAN	CAN1
4	CAN1_L		
14	CAN2_H	CAN	CAN2
15	CAN2_L		
16	EVENT_GNSS	3.3V CMOS	
17	GND_GNSS		
18	PPS	3.3V CMOS	

The equipment is connected to external systems and power supplies via communication cables. One end of the communication cable is a J30JZ/XN21TJCAL01 connector for connecting to the system, and the other end splits into power lines and communication lines.

Communication Cable Instructions：

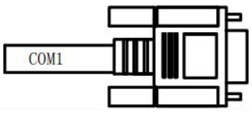
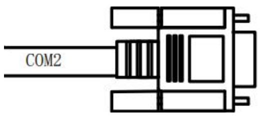
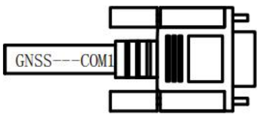
Power Line: Connect to 9~36V DC power. When supplied with 24V, the operating current should not exceed 0.4A, The external wiring is exposed.

Communication Line: has 3 serial ports, 2 CAN ports, 1 PPS interface, and 1 EVENT interface. Among them, COM1 is a protocol output interface for RS-232; COM2 is a protocol output interface for RS-422; COM1_GNSS is the COM1 for the direct-connection satellite receiving board card, using RS-232. The specific configuration and functions of the serial ports are shown in Table 3.The serial ports are all BD9 female headers. The CAN interface, PPS interface, and EVENT interface are exposed wiring interfaces. The cable description is shown in Table 4.

Table 3 Interface settings and functions.

Interface	Buadrate	Function	Remarks
COM1	460800	Data output and configuration interface	
COM2	460800	Data output and configuration interface	
GNSS_COM1	115200	GNSS configuration/GNSS data/RTK	direct to GNSS
CAN1	250K/500k	CAN1 is externally connected to wheel speed CAN2 for data output	

Table 4 Interface settings and function

Interface	Cable Label	Pin No.	Description	Tag/Color	Port
COM1		3	R		DB9 female
		2	T		
		5	GND		
COM2		1	R+		DB9 female
		2	R-		
		3	T+		
		4	T-		
COM1-GNSS		3	R		DB9 female
		2	T		
		5	GND		
EVENT+PPS				EVENT-GNSS	lines
				PPS	
				GND	
Power supply			VIN	Red	lines
			VIN	Red	
			GND		
			GND		
CAN			CAN1-H		lines
			CAN1-L		
			CAN2-H		
			CAN2-L		

3.Quick Start

3.1. Installation

Fix the integrated navigation product with the X - right, Y - front, and Z - up axial inertia on the working carrier. Fix the main antenna at a position as close as possible to the integrated navigation product. Fix the slave antenna directly in front of the main antenna (Note: The carrier, integrated navigation, and GNSS antenna must be strictly rigidly connected).

For other installation methods, refer to the selection angle and lever arm settings in the system settings.

3.2. Connecting Cables

Use radio frequency cables to connect the GNSS main and slave antennas. Connect the power supply through the main cable and select an appropriate communication interface to connect to the upper computer as required. Ensure a tight connection.

3.3. Product Configuration

You can use the SET VEHICLE command to select the working carrier suitable for the application scenario. For non - standard installations, use the upper computer to configure the lever arm, selection angle, and the required data output protocol. After configuration, restart and check whether the configuration takes effect.

3.4. Completion

After completing the configuration, connect the power supply, and the combined navigation product can be used normally.

4.Datagram protocal

The output datagram protocols supported by the product are shown in Table 5.

Table 5 Description of output datagram protocol

No.	Protocal Name	Type	Output Type
1	inspvaxb	Binary	1/5/10/20/25/50/100Hz/200Hz
2	gnss	Binary	1/5/10Hz
3	odm	Binary	Decided by input frequency
4	rawimusb	Binary	1/5/10/20/25/50/100Hz/200Hz
5	bdfpdl	ASCII	1/5/10/20/25/50/100Hz/200Hz
6	inspvasa	ASCII	1/5/10/20/25/50/100Hz/200Hz

Note:

A high output frequency should correspond to a high baud rate; otherwise, it will cause the serial port to freeze. For example, the datagram requested INSPVAXB 100Hz, GNSS 10Hz, and RAWIMUSB 100Hz, need the baud rate as 460800.

4.1. INSPVAXB

Table 6 INSPVAXB data protocol

<table>
<tr><th>No.</th><th colspan="2">Name</th><th>Description</th><th>Format</th><th colspan="2">Bytes</th><th>Byte offset</th><th>Remarks</th></tr>
<tr><td>1</td><td rowspan="16">Header</td><td>Frame header</td><td>0xAA</td><td>Uchar</td><td>1</td><td rowspan="16">H</td><td rowspan="16">0</td><td></td></tr>
<tr><td>2</td><td>Frame header</td><td>0x44</td><td>Uchar</td><td>1</td><td></td></tr>
<tr><td>3</td><td>Frame header</td><td>0x12</td><td>Uchar</td><td>1</td><td></td></tr>
<tr><td>4</td><td>Message head length</td><td>0x1C=28</td><td>Uchar</td><td>1</td><td></td></tr>
<tr><td>5</td><td>Information ID</td><td>0x5B9</td><td>Ushort</td><td>2</td><td></td></tr>
<tr><td>6</td><td>Type of information</td><td>0x00</td><td>Char</td><td>1</td><td></td></tr>
<tr><td>7</td><td>Port address</td><td>0xA0</td><td>Uchar</td><td>1</td><td></td></tr>
<tr><td>8</td><td>Message length</td><td>0x7E=126, without header and CRC</td><td>Ushort</td><td>2</td><td></td></tr>
<tr><td>9</td><td>Sequence</td><td>0x00</td><td>Ushort</td><td>2</td><td></td></tr>
<tr><td>10</td><td>Idle Time</td><td>0x00</td><td>Uchar</td><td>1</td><td></td></tr>
<tr><td>11</td><td>Time state</td><td>Invalid: 0x14
valid:0xB4</td><td></td><td>1</td><td></td></tr>
<tr><td>12</td><td>GPS Week</td><td></td><td>Ushort</td><td>2</td><td>—</td></tr>
<tr><td>13</td><td>GPS periods per second</td><td>unit: ms</td><td>GPSec</td><td>4</td><td></td></tr>
<tr><td>14</td><td>Accepting state</td><td>0x00</td><td>Ulong</td><td>4</td><td></td></tr>
<tr><td>15</td><td>Reserve 1</td><td>0x46EB</td><td>Ushort</td><td>2</td><td></td></tr>
<tr><td>16</td><td>Reserve 2</td><td>0x411A</td><td>Ushort</td><td>2</td><td></td></tr>
</table>

No.	Name	Description	Format	Bytes	Byte offset	Remarks
17	Combined navigation status	Alignment: 1 Navigation: 3	—	4	H	—
18	Locate the type	Locate type, see Table 7	—	4	H+4	
19	Latitude	Unit: degree	Double	8	H+8	
20	Longitude	Unit: degree	Double	8	H+16	
21	Height (ellipsoidal height)	unit: m	Double	8	H+24	
22	Sliding values of ellipsoids	unit: m	Float	4	H+32	
23	North speed	unit: m/s	Double	8	H+36	
24	East speed	unit: m/s	Double	8	H+44	
25	The day speed	unit: m/s	Double	8	H+52	
26	Roll	Roll Angle-180 degrees ~180 degrees Unit: degree	Double	8	H+60	
27	Pitch	Pitch angle-90 degrees ~90 degrees Unit: degree	Double	8	H+68	
28	Heading	Heading Angle: 0 - 360°, clockwise direction Unit: degree	Double	8	H+76	
29	Latitude standard deviation	unit: m	Float	4	H+84	—
30	Longitude standard deviation	unit: m	Float	4	H+88	
31	Highly standard deviation	unit: m	Float	4	H+92	
32	North speed standard deviation	unit: m/s	Float	4	H+96	
33	East speed standard deviation	unit: m/s	Float	4	H+100	
34	Standard deviation of day speed	unit: m/s	Float	4	H+104	
35	Standard deviation of the horizontal roll angle	Unit: degree	Float	4	H+108	
36	Standard deviation of the pitch angle	Unit: degree	Float	4	H+112	
37	Standard deviation of the heading angle	Unit: degree	Float	4	H+116	
38	Extension status and update flag	See Table 8	—	4	H+120	
39	Reserved	—	—	2	H+124	
40	check sum	The 32-bit CRC calibration is performed	Uint	4	H+126	—

Table 7 Position the type status flag

Order number	Type declaration	Corresponding sign	Corresponding ASCII
1	Invalid positioning	0	NONE
2	Single point solution	53	INS_PSRSP
3	Differential positioning	54	INS_PSRDIFF
4	RTK fixed solution	56	INS_RTKFIXED
5	RTK floating point solution	55	INS_RTKFLOAT
6	Recursion	52	INS_SBAS

Table 8 Extension status and update flag

Order number	Type declaration	Corresponding sign
1	Aim at	0x00000000
2	Inertial calculation	0x00000800
3	Satellite navigation update	0x00000001
4	Wheel speed update	0x00000008
5	Satellite navigation + wheel speed update	0x00000009
6	The kinetic filtering	0x00000400

4.2. RAWIMUSB

Table 9 RAWIMUSB data protocol

No.	Name		Description	Format	Bytes		Byte offset	Remarks
1	Header	Frame header	0xAA	—	1	H	0	
			0x44	—	1			
			0x13	—	1			
2		Message length	0x28=40, without header and CRC	—	1			
3		Information ID No	0x145	—	2			—
4		GNSS Week	—	Ushort	2			—
5		Periods per second	unit: ms	Uint	4			—
6	Reserved position		—	—	2		H	
7	GNSS Week		—	Uint	2		H+2	
8	Periods per second		unit: s	Double	8		H+4	
9	IMU status word		See Table 10	Uint	2		H+12	
10	Temperature		—	Uint	2		H+14	Divide by 100
11	Z output to the accelerometer (top)		unit: g	Long	4		H+16	Proportional coefficient: 52621241.37840640 (Output divided by proportional factor)
12	-Y output to the accelerometer (after)		unit: g	Long	4		H+20	

No.	Name	Description	Format	Bytes	Byte offset	Remarks
13	X-output to the accelerometer (right)	unit: g	Long	4	H+24	g=9.80147 m/s2
14	Z output to the gyroscope (top)	unit:°/s	Long	4	H+28	Proportion coefficient: 1499226.41161356 (Output divided by proportional factor)
15	-Y Output to the gyroscope (rear)	unit:°/s	Long	4	H+32	
16	X-output to the gyroscope (right)	unit:°/s	Long	4	H+36	
17	check sum	The 32-bit CRC calibration is performed	Uint	4	H+40	

Order number	Type declaration	Binary bit	Corresponding sign
1	X gyro state	D15	1: Normal, 0: fault
2	Y gyro state	D14	
3	Z gyro state	D13	
4	reserve	D12	
5	X accelerometer status	D11	1: Normal, 0: fault
6	Y accelerometer status	D10	
7	Z-accelerometer status	D9	
8	reserve	D8~D0	—

Table 10 IMU status description

4.3. GNSS

GNSS refers to satellite navigation data, with the specific protocol format detailed in Table 11.

Table 11 Description of the GNSS data protocol

No.	Name		Description	Format	Bytes		Byte offset	Remarks
1	Header	Frame header	0xAA	—	1	H	0	
			0x44	—	1			
			0xBD	—	1			
2		Message length	0x6C=108, without header and CRC	—	1			
3		Information ID	0x0075		2			

<table>
<tr><th>No.</th><th colspan="2">Name</th><th>Description</th><th>Format</th><th>Bytes</th><th>Byte offset</th><th>Remarks</th></tr>
<tr><td></td><td rowspan="3"></td><td>No</td><td></td><td></td><td></td><td rowspan="3"></td><td></td></tr>
<tr><td>4</td><td>GPS Week</td><td></td><td>Ushort</td><td>2</td><td></td></tr>
<tr><td>5</td><td>GPS periods per second</td><td>unit: s</td><td>Uint</td><td>4</td><td></td></tr>
<tr><td rowspan="7">6</td><td rowspan="7">UTC time</td><td>Time valid mark</td><td></td><td>UChar</td><td>1</td><td>H</td><td>Bit 0-time seconds valid
Bit 1-year month valid</td></tr>
<tr><td>Year</td><td></td><td>Ushort</td><td>2</td><td>H+1</td><td></td></tr>
<tr><td>Moon</td><td></td><td>UChar</td><td>1</td><td>H+3</td><td></td></tr>
<tr><td>Sun</td><td></td><td>UChar</td><td>1</td><td>H+4</td><td></td></tr>
<tr><td>Time</td><td></td><td>UChar</td><td>1</td><td>H+5</td><td></td></tr>
<tr><td>Component</td><td></td><td>UChar</td><td>1</td><td>H+6</td><td></td></tr>
<tr><td>Second</td><td></td><td>Float</td><td>4</td><td>H+7</td><td></td></tr>
<tr><td>7</td><td colspan="2">Locate the logo</td><td>See Table 12</td><td>UChar</td><td>1</td><td>H+11</td><td></td></tr>
<tr><td>8</td><td colspan="2">Number of satellites used</td><td>unit: a</td><td>UChar</td><td>1</td><td>H+12</td><td></td></tr>
<tr><td>9</td><td colspan="2">Track the number of satellites</td><td>unit: a</td><td>UChar</td><td>1</td><td>H+13</td><td></td></tr>
<tr><td>10</td><td colspan="2">The number of dual-frequency satellites is used</td><td>unit: a</td><td>UChar</td><td>1</td><td>H+14</td><td></td></tr>
<tr><td>11</td><td colspan="2">Health guide positioning frequency</td><td>unit: Hz</td><td>UChar</td><td>1</td><td>H+15</td><td></td></tr>
<tr><td>12</td><td colspan="2">PDOP</td><td></td><td>Float</td><td>4</td><td>H+16</td><td></td></tr>
<tr><td>13</td><td colspan="2">HDOP</td><td></td><td>Float</td><td>4</td><td>H+20</td><td></td></tr>
<tr><td>14</td><td colspan="2">Longitude</td><td>unit: degree</td><td>Double</td><td>8</td><td>H+24</td><td></td></tr>
<tr><td>15</td><td colspan="2">Latitude</td><td>unit: degree</td><td>Double</td><td>8</td><td>H+32</td><td></td></tr>
<tr><td>16</td><td colspan="2">Height (ellipsoidal height)</td><td>unit: m</td><td>Float</td><td>4</td><td>H+40</td><td></td></tr>
<tr><td>17</td><td colspan="2">East speed</td><td>unit: m/s</td><td>Float</td><td>4</td><td>H+44</td><td rowspan="3"></td></tr>
<tr><td>18</td><td colspan="2">North speed</td><td>unit: m/s</td><td>Float</td><td>4</td><td>H+48</td></tr>
<tr><td>19</td><td colspan="2">The day speed</td><td>unit: m/s</td><td>Float</td><td>4</td><td>H+52</td></tr>
<tr><td>20</td><td colspan="2">Standard deviation of the ECEF _ X position</td><td>unit: m</td><td>Float</td><td>4</td><td>H+56</td><td rowspan="3"></td></tr>
<tr><td>21</td><td colspan="2">Standard deviation of the ECEF _ Y position</td><td>unit: m</td><td>Float</td><td>4</td><td>H+60</td></tr>
<tr><td>22</td><td colspan="2">Standard deviation of the ECEF _ Z position</td><td>unit: m</td><td>Float</td><td>4</td><td>H+64</td></tr>
<tr><td>23</td><td colspan="2">Standard deviation of the east velocity</td><td>unit: m/s</td><td>Float</td><td>4</td><td>H+68</td><td rowspan="2"></td></tr>
<tr><td>24</td><td colspan="2">Standard deviation of the north velocity</td><td>unit: m/s</td><td>Float</td><td>4</td><td>H+72</td></tr>
</table>

No.	Name	Description	Format	Bytes	Byte offset	Remarks
25	Standard deviation of the day velocity	unit: m/s	Float	4	H+76	
26	Height anomaly	unit: m	Float	4	H+80	
27	Ground velocity	unit: m/s	Float	4	H+84	
28	Heading angle	Course angle 0 to 360 degrees, clockwise Unit: degree	Float	4	H+88	
29	The heading Angle sign	Invalid: 0 valid:1	UChar	1	H+92	
30	Reserved position			15	H+93	
31	check sum	The 32-bit CRC calibration is performed	Uint	4	H+108	

Table 12 Positioning type and positioning flag

No.	Type declaration	Corresponding sign
1	Invalid solution	0
2	Single point solution	1
3	Finite difference solution	2
4	Floating point solution	5
5	Narrow fixed solution (narrow int)	4
6	Other fixed solutions	7

4.4. ODM

ODM is the odometer information. The specific protocol format is shown in the following Table 13:

Table 13 ODM data protocol description

No.	Name		Description	Format	Bytes		Byte offset	Remarks
1	Header	Frame header	0xaa	Uchar	3	H	0	
			0x44					
			0x13					
2		Message length	0x18=24, without header and CRC		1			
3		Information ID	0x38F		2			
4		GNSS Week		Ushort	2			
5		Periods per second	unit: s	Uint	4			
6	Turn to information		Unit: degree	Double	8		H	

No.	Name	Description	Format	Bytes	Byte offset	Remarks
7	Wheel speed-right back	unit: m/s	Float	4	H+8	
8	Wheel speed-front right	unit: m/s	Float	4	H+12	
9	Wheel speed-left back	unit: m/s	Float	4	H+16	
10	Wheel speed-front left	unit: m/s	Float	4	H+20	
11	check sum	The 32-bit CRC calibration is performed	Uint	4	H+24	

4.5. BDFPDL

Table 14 Description of the GNSS data protocol

No.	Name	Description	Format	Bytes
1	$BDFPDL	Format head	—	—
2	GPS Week	Current number of weeks since 1980-1-6 (GMT)	integer	—
3	GPS periods per second	GPS periods per second	Floating point type	s
4	Heading angle	Yaw angle 0~360 degrees, clockwise direction	Floating point type	degree
5	Pitch angle	Pitch angle-90 degrees ~90 degrees	Floating point type	degree
6	Roll position	Roll Angle-180 degrees ~180 degrees	Floating point type	degree
7	Latitude	Combined output latitude-90 degrees ~90 degrees	Floating point type	degree
8	Longitude	Combined output is longitude-180 degrees ~180 degrees	Floating point type	degree
9	Altitude	The height of the combined output	Floating point type	m
10	East speed	Combined output east speed	Floating point type	m/s
11	North speed	Combination output north speed	Floating point type	m/s
12	The day speed	Combination output day speed	Floating point type	m/s
13	X axis angular rate	IMU line right	Floating point type	°/s
14	-Y-axis angle rate	Before the IMU lineage	Floating point type	°/s
15	Z axis angular rate	IMU to fasten	Floating point type	°/s
16	X axis acceleration	IMU line right	Floating point	m/s2

No.	Name	Description	Format	Bytes
			type	
17	-Y-axis acceleration	IMU before the line	Floating point type	m/s2
18	Z axis acceleration	IMU to fasten	Floating point type	m/s2
19	NSV1	Antenna 1 number of satellites	integer	a
20	NSV2	Antenna 2 number of satellites	integer	a
21	Locate the type	See Table 15	integer	—
22	Directional type	See Table 15	integer	—
23	System status word	0x00: Standby 0x10: coarse alignment 0x20: Fine alignment 0x30: Combined navigation 0x31: Combined navigation		
24	check code	check code	hexadecimal	—
25	< CR><LF>	Fixed package tail	—	—

Table 15 Positioning type and positioning flag

Order number	Type declaration	Corresponding sign
0	Invalid positioning	0
1	Single point solution	16
2	Differential positioning	17
3	L1 floating point solution	32
4	RTK, and the floating-point solution	34
5	L1 fixed solution	48
6	RTK fixed solution	50

4.6. INSPVASA

Table 16 INSPVASA data protocol

No.	Name	Description	Format	Bytes
1	%INSPVASA	Format head	—	—
2	GPS Week	Current number of weeks since 1980-1-6 (GMT)	integer	—
3	GPS periods per second	GPS periods per second	Floating point type	s
4	GPS Week	Current number of weeks since 1980-1-6 (GMT)	integer	—
5	GPS periods per	GPS periods per second	floating	s

No.	Name	Description	Format	Bytes
	second		number	
6	Latitude	Combined output latitude-90 degrees ~90 degrees	Floating point type	linear measure
7	Longitude	Combined output is longitude-180 degrees ~180 degrees	Floating point type	linear measure
8	Altitude	The height of the combined output	Floating point type	m
9	North speed	Combination output north speed	Floating point type	m/s
10	East speed	Combined output east speed	Floating point type	m/s
11	The day speed	Combination output day speed	Floating point type	m/s
12	Roll position	Roll Angle-180 degrees ~180 degrees	Floating point type	linear measure
13	Pitch angle	Pitch angle-90 degrees ~90 degrees	Floating point type	linear measure
14	Heading angle	Yaw angle 0-360 degrees, clockwise	Floating point type	linear measure
15	INS state	See Table 17	—	—
16	check code	Check code (number of 32-bit CRC check between% and *)	hexadecimal	—
17	< CR><LF>	Fixed package tail	—	—

Table 17 The INS status word description

INS status word	State 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.

5.Configuration Commands

5.1. Device Reset

This command is used for software reset and restart of the integrated navigation device.

RESET

Command Header	Function	Parameter	Parameter Range	Description
RESET				Restart the integrated navigation device

Example: RESET

5.2. Restore Factory Default Settings

This command is used to restore the default configuration and restart the integrated navigation device.

FRESET

Command Header	Function	Parameter	Parameter Range	Description
FRESET				Restore the default configuration and restart the integrated navigation device

Example: FRESET

5.3. Save Settings

This command is used to save the current settings

SAVECONFIG

Command Header	Function	Parameter	Parameter Range	Description
SAVECONFIG				Save the current settings

Example: SAVECONFIG

5.4. Set Data Output

LOG [PORT] [Message ID] [Trigger] [Period]

Command Header	Function	Parameter	Parameter Range	Description
LOG		PORT	COM1,COM2,SD,CAN,STH	Physical port number of the device
		Message	See Table 6	Specify the output data format
		Trigger	ONTIME	Fixed time interval trigger output
		Period	0.005，0.01,0.02,0.04,0.05,0.1,0.2,1	Output time interval, unit: s

Example: LOG COM1 INSPVAXB ONTIME 0.01

Output refers to the following table

No.	Protocal Name	Type	Output Type
1	inspvaxb	Binary	1/5/10/20/25/50/100Hz/200Hz
2	gnss	Binary	1/5/10Hz
3	odm	Binary	Decided by input frequency
4	rawimusb	Binary	1/5/10/20/25/50/100Hz/200Hz
5	bdfpdl	ASCII	1/5/10/20/25/50/100Hz/200Hz
6	inspvasa	ASCII	1/5/10/20/25/50/100Hz/200Hz

5.5. Set to Close Data Output

This command is used to close the output of the specified data for this port.

UNLOG [PORT] [Message ID]

Command Header	Function	Parameter	Parameter Range	Description
UNLOG		PORT	COM1,COM2,SD,CAN,ETH	Physical port number of the device
		Message	Same as LOG command	Specify the data format to be closed

Example: UNLOG COM1 INSPVAXB

5.6. Set to Close All Data Output

This command is used to close all data output of this port.

UNLOGALL [PORT]

Command Header	Function	Parameter	Parameter Range	Description
UNLOGALL		PORT	COM1, COM2, SD,CAN,STH	Physical port number of the device

Example: UNLOGALL COM1

5.7. Set GNSS Transparent Transmission Function

This command is used to enable the GNSS transparent transmission function. Once enabled, the output content of COM2 of the GNSS module will be directly forwarded to the specified port. It is required that the baud rate of COM2 of the GNSS module is configured as 460800.

SET GNSSDT [OPTION]

Command Header	Function	Parameter	Parameter Range	Description

SET	GNSSDT	OPTION	ETH	GNSS data forwarded to the network port
			SD	GNSS data forwarded to SD card
			COM1	GNSS data forwarded to COM1
			DISABLE	Disable GNSS data forwarding

Example: SET GNSSDT SDCARD

5.8. Set Serial Port Baud Rate

This command is used to set the serial port baud rate.

SET COMCONFIG [COM] [Baud Rate]

Command Header	Function	Parameter	Parameter Range	Description
SET	COMCONFIG	COM	COM1,COM2	Physical port number of the device
		Baud Rate	9600,38400,115200, 230400,460800,921600	The baud rate can be set within the specified parameter range. Note that COM1 cannot be set to 921600.

SET COMCONFIG COM1 460800

5.9. Set the Lever Arm from INS to Main/Sub - Antenna

This command is used to configure the lever arm of the main and sub - antennas. The lever arm uses the coordinate description of the phase center of the antenna in the carrier system (navigation coordinate system).

SET INSTOANTOFFSET [ANT] [X] [Y] [Z]

Command Header	Function	Parameter	Parameter Range	Description
SET	INSTOANT OFFSET	ANT	ANT1	Main antenna
			ANT2	Sub - antenna
		X	[-100,+100]	Unit: meter, can be accurate to 3 decimal places
		Y	[-100,+100]	Unit: meter, can be accurate to 3 decimal places
		Z	[-100,+100]	Unit: meter, can be accurate to 3 decimal places

Example: SET INSTOANTOFFSET ANT1 -0.537 -0.287 0.866

5.10. Set Output Position to INS Lever Arm

This command is used to configure the output position offset lever arm. The lever arm uses the coordinate description of the output position offset point in the carrier system (navigation reference coordinate system).

SET INSOFFSET [X] [Y] [Z]

Command Header	Function	Parameter	Parameter Range	Description
SET	INSOFFSET	X	[-100,+100]	Unit: meter, can be accurate to 3 decimal places
		Y	[-100,+100]	Unit: meter, can be accurate to 3 decimal places
		Z	[-100,+100]	Unit: meter, can be accurate to 3 decimal places

Example: SET INSOFFSET 0.627 -0.332 0.746

5.11. Set Rotation Angle from INS to IMU (INS to IMU Configuration)

This command is used to configure the rotation relationship between the carrier system (navigation reference coordinate system) and the IMU coordinate system. It is defined as rotating by the angles of Z, X, and Y in sequence according to the rotation order of “z→y→x” in the carrier system to the IMU coordinate system.

SET INSROTATION [X] [Y] [Z]

Command Header	Function	Parameter	Parameter Range	Description
SET	INSROTATION	X	[-90,90]	Unit: meter, can be accurate to 2 decimal places
		Y	[-180,180]	Unit: meter, can be accurate to 2 decimal places
		Z	[0,360]	Unit: meter, can be accurate to 2 decimal places

Example: SET INSROTATION 16.33 3.48 5.11

5.12. Set Rotation Angle from INS to Output Reference System

This command is used to configure the rotation relationship between the carrier system (navigation reference coordinate system) and the output reference coordinate system. It is defined as rotating by the angles of Z, X, and Y in sequence according to the rotation order of “z→y→x” in the carrier system to the output reference coordinate system.

SET INSTOREF [X] [Y] [Z]

Command Header	Function	Parameter	Parameter Range	Description
SET	INSTOREF	X	[-90,90]	Unit: degree, can be accurate to 2 decimal places
		Y	[-180,180]	Unit: degree, can be accurate to 2 decimal places
		Z	[0,360]	Unit: degree, can be accurate to 2 decimal places

Example: SET INSTOREF 12.23 54.44 90.76

5.13. Set Dual - Antenna Observation Function

This command is used to set the dual - antenna observation function, switching the heading correction source of GNSS between the dual - antenna heading angle and the yaw angle.

SET ANT2 [OPTION]

Command Header	Function	Parameter	Parameter Range	Description
SET	ANT2	OPTION	ENABLE	Enable dual-antenna observation
			DISABLE	Disable dual-antenna observation (single-antenna mode)

Example: SET ANT2 ENABLE

5.14. Set Vehicle Dynamics Constraint Function

This command is used to set the vehicle dynamics constraint model. It is recommended to enable this dynamics model for carriers similar to vehicles (without lateral and vertical velocities), which can improve the accuracy.

SET GVR [MODE]

Command Header	Function	Parameter	Parameter Range	Description
SET	GVR	MODE	ENABLE	Enable
			DISABLE	Disable

SET GVR ENABLE

5.15. Set Position Smoothing Function

This command is used to set the position smoothing filter, which can switch between two strategies to perform smoothing processing on the position output by the integrated navigation system.

SET SMFT [MODE]

Command Header	Function	Parameter	Parameter Range	Description
SET	SMFT	MODE	ALL	Full - process smoothing
			OUTAGE	GNSS outage smoothing
			NONE	No smoothing

SET SMFT OUTAGE

5.16. Set Zero - Velocity Correction Function

This command is used to set the zero - velocity correction function. When enabled, the integrated navigation system will automatically detect whether the carrier is stationary. When stationary is detected, the zero - velocity correction will be activated. It is recommended to enable this for vehicle - type carriers, which can improve the accuracy.

SET ZUPT [MODE]

Command Header	Function	Parameter	Parameter Range	Description
SET	ZUPT	MODE	ENABLE	Enable
			DISABLE	Disable

SET ZUPT ENABLE

5.17. Set Heading Reliability Screening Function

This command is used to set heading reliability screening. When enabled, the heading observations of the GNSS dual antennas will be subjected to reliability screening before being used. It is recommended to enable it in a GNSS signal - poor environment. However, in scenarios with a lot of swaying, it may lead to the problem of fewer available heading observations.

SET HAJ [MODE]

Command Header	Function	Parameter	Parameter Range	Description
SET	HAJ	MODE	ENABLE	Enable
			DISABLE	Disable

SET HAJ ENABLE

5.18. Set Carrier Mode

This command is used to quickly set the carrier used by the integrated navigation device. It will automatically configure functions such as vehicle dynamics constraint, zero velocity, zero velocity correction, and heading reliability screening according to the selected carrier.

SET VEHICLE [MODE]

Command Header	Function	Parameter	Parameter Range	Description
SET	VEHICLE	MODE	CAR	Vehicle: almost no lateral and longitudinal displacement during movement
			MARINE	Marine carrier
			AIR	Fixed - wing aircraft, UAV
			PLATFORM	Stabilized platform

6. System Settings

The system configuration of the product is shown in the following below

Table 18 List of configuration items

Order number	CI	Remarks
1	GNSS antenna rod arm value configuration	
2	Output rod and arm value configuration	
3	Rotation Angle configuration	
4	Output rotation angle configuration	
5	Vehicle dynamics constraint configuration	
6	Lost recovery and smooth transition configuration	
7	Parameter storage configuration	

Note:

Device configuration recommends to read the configuration first, then modify the configuration, and write the configuration after the modification, such as Figure 4 shown.

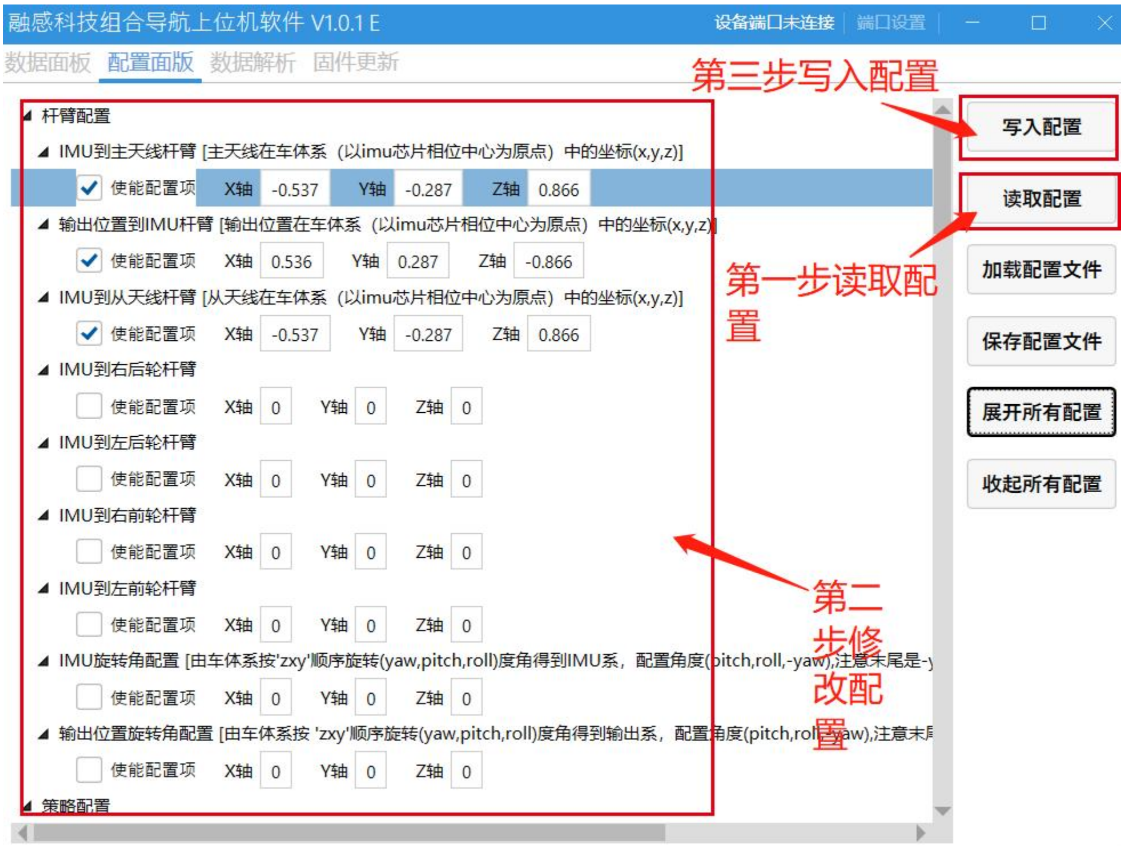


Figure 4 Configuration flow chart

6.1. GNSS antenna lever arm value configuration

According to the relative installation relationship between the antenna and the combined navigation system, the antenna lever arm configuration is required. With the arm value between the combined navigation system and the antenna, the measurement must be accurate to millimeter, especially for RTK operation, any arm measurement error will directly enter into the position error of the output of the combined navigation system.

The configuration includes the main antenna lever arm configuration and the antenna rod arm configuration, which can be configured through “Integrated Navigation Upper Computer Software”. After the configuration is completed, click write configuration, such as Figure 5 shown.

Figure 5 Parameter configuration diagram of the antenna rod and arm value

The lever arm value is meters, which represents the component of the vector from the combined navigation system to the phase center of the antenna in the carrier coordinate system of the combined navigation system. The carrier coordinate system of the combined navigation system is selected as the upper right front (XYZ). Figure 6 Example, X and Y should be negative and Z should be positive.

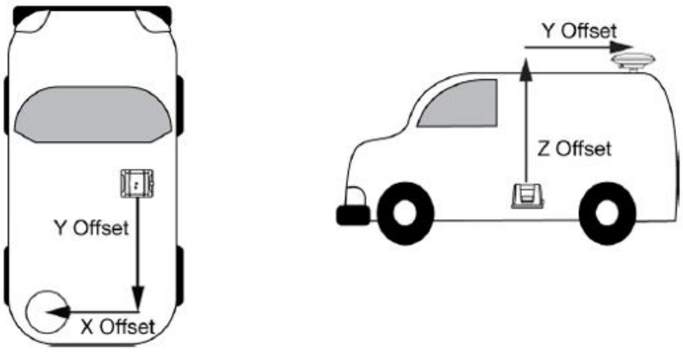


Figure 6 Schematic diagram of the antenna rod arm

6.2. Output lever arm value configuration

The default value of the product output lever arm configuration is [0,0,0] (top right), which is the position and speed value of the output combination navigation system. If the position and speed of the user test point should be output, the output lever arm should be set according to the relative installation relationship between the test point and the combined navigation system.

To configure the lever arm value between the combined navigation system and the test point, the measurement must be accurate to mm (mm), especially for RTK operation, any arm measurement error will directly into the position error of the output of the combined navigation system.

The output lever arm configuration can be configured through the computer software. After the configuration is completed, click write configuration. After the device is restarted, the configuration takes effect, such as Figure 7 shown.

Figure 7 Parameter configuration diagram of the output rod and arm value

The lever arm value is meters, which represents the component of the vector from the test point to the combined navigation system in the combined navigation system. The carrier coordinate system of the combined navigation system is selected as the right front (XYZ). Figure 8 Example, assuming the measurement point is the antenna position, then X and Y should be negative and Z should be positive.

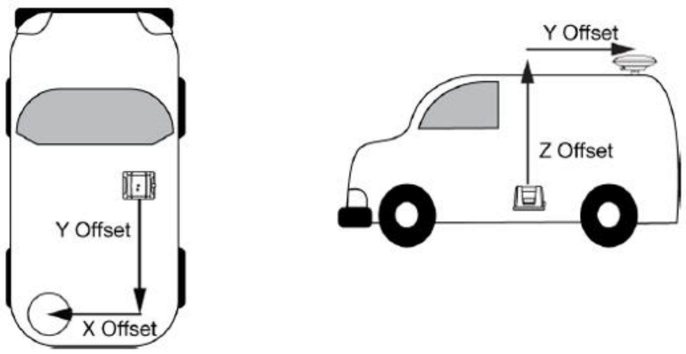


Figure 8 Schematic diagram of the output rod and arm

6.3. Rotation Angle configuration

The attitude and heading information of the product output are the 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 value is [0,0,0] (pitch Angle X, roll Angle Y, heading Angle Z), that is, the product coordinate system is considered to coincide with the installation carrier coordinate system. If the product is installed on the carrier and requires the output angle of the product relative to the carrier system, the rotation Angle shall be set according to the relative installation relationship between the product and the carrier.

The rotation angle configuration can be configured through the computer software. After the configuration is completed, click write configuration, and the device is restarted, such as Figure 9 shown.

Figure 9 Rotation angle parameter configuration diagram

The configured rotation angle value is degree, representing the angle from the carrier coordinate system to the combined navigation system coordinate system. The order is Z axis, X axis and Y axis, and the rotation angle is Angle (-Z), Angle X and Angle Y.

6.4. Output rotation angle configuration

The output rotation angle, the default value is [0,0,0] (Angle X, Angle Y, Angle Z), namely, the attitude and heading information of the output combined navigation system relative to the geographic system. If the user needs to output the coordinate system relative to the geographic system, the output position rotation angle shall be configured.

The output position rotation angle configuration can be configured through the upper computer software. After the configuration is completed, click write configuration, and after the device restart, the configuration takes effect, such as Figure 10.

Figure 10 The diagram of output position

The rotation Angle of the output position means the Euler Angle of the user coordinate system (the carrier rotates to the user coordinate system) in the degree. The rotation order of the coordinate system from the combined navigation system to the coordinate system of the user is Z axis, X axis and Y axis, the rotation direction follows the right hand rule, and the rotation Angle is Angle (-Z), Angle X and Angle Y.

6.5. Vehicle dynamics type configuration

The vehicle dynamics type should be configured depend on the vehicle type. If the vehicle is a normal car, this configuration should be enable to improve the position accuracy during GNSS outage. For other vehicle such as drone, ships and so on, please disable. After the configuration is complete, click Write configuration, and after the device restart, the configuration takes effect, such as Figure 11.

Figure 11 Vehicle dynamics constraint configuration diagram

6.6. Outage and restore smooth configuration

Outage and restore smooth transition configuration is suitable for higher requirements for position smoothness than absolute accuracy, start the function in the satellite signal loss lock recovery, the combined navigation system output position as smooth as possible to the current reliable position, close the function combined navigation system position will immediately return to a reliable position. Users can configure through the upper machine according to their own needs, and select to open or close. After the configuration is completed, click to write the configuration, and after the device restart, the configuration takes effect, such as Figure 12 shown.

Figure 12 Lock-out recovery smooth transition configuration diagram

6.7. Error calibrate configuration

The error calibrate configuration is NOT necessary. It's used for calibration installation error parameters (such as installation error angle, lever arm error, etc.), so as to be used as initial values in subsequent use to speed up convergence. This function is suitable for the fixed installation case. In order to get accurate parameters, the calibration should be run in a recommended process.

It is recommended to select to enable calibration once option. After the configuration is completed, click Write Configuration. After the device is restarted, the configuration takes effect, such as Figure 13 shown.

Recommended process: first stay for 3min, then driving in straight line with the speed more than 60 km/h, then turn right and left (for example move as “8”), and finally diving normally for 30min (all in open sky).

Attention:

1) After reinstalling the equipment, it needs to be re-calibrated, otherwise it will lead to parameter mismatch and poor navigation accuracy;
2) For a long time, in order to ensure the navigation accuracy, it is recommended to recalibrate;
3) It is recommended to select to enable the primary parameter storage option and write to the configuration.

Figure 13 Parameters to store the configuration diagram

7. CAN port configuration

7.1. CAN port configuration

The product supports CAN port communication, and you need to check the enabling configuration item (the current CAN output does not support changing the port rate, the default is 500 KHZ). After the configuration is completed, click write configuration, such as Figure 14 shown.

Figure 14 CAN port parameter configuration diagram

7.2. CAN output protocol

CAN network port-supported communication protocols such as shown in Table 19, the configuration of the CAN protocol output frequency can be realized through the GNSS and INSPVA frequencies in the CAN output configuration option of the upper computer software, where the GNSS and INSPVA correspond to the ID number of the CAN protocol and the protocol frequency corresponding configuration such as shown in Table 21, after the configuration is complete, click Write configuration, as shown in Figure 15.

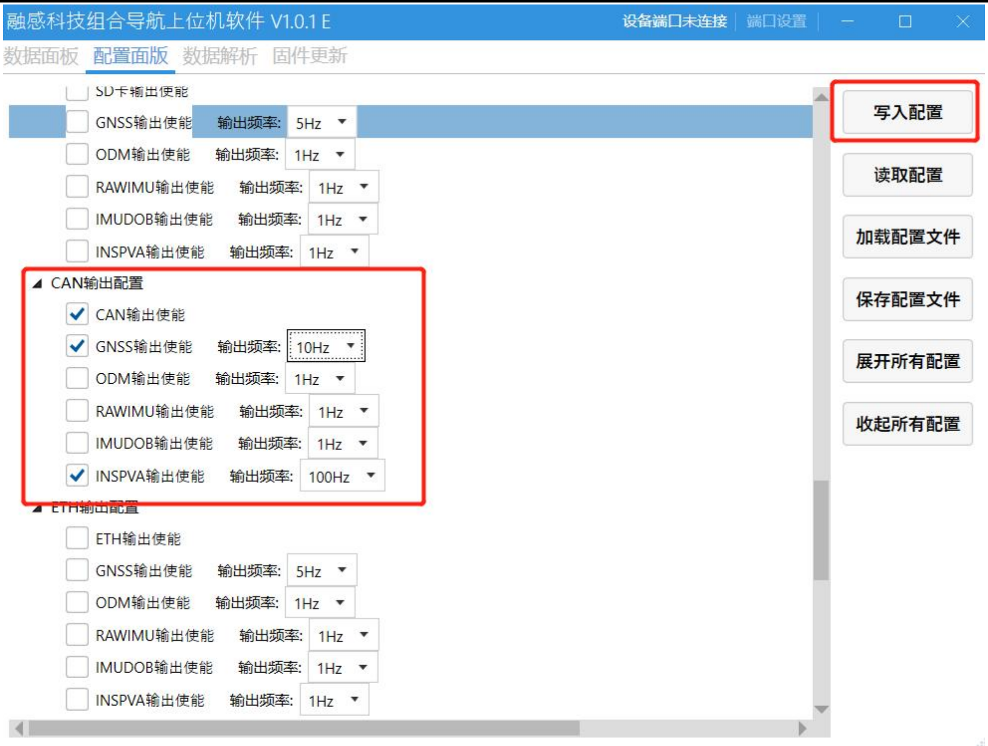


Figure 15 CAN port output protocol configuration

Table 19 CAN protocol

A. ID: 0X10B，DLC=6，three-axis attitude: heading, pitch, roll

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	U	Degrees	1e-2	heading
2	2	S	Degrees	1e-2	pitch
4	2	S	Degrees	1e-2	roll

B. ID: 0x20B，DLC=8，latitude and longitude

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	Degrees	1e-7	Lat
4	4	S	Degrees	1e-7	Lon

C. ID: 0x30B，DLC=5，height and navigation state

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	m	1e-3	Alt
4	1	U	NULL	1	Flag （see Table 20）

D. ID: 0x40B，DLC=6，three-way velocity

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	S	m/s	1e-2	East Velocity

2	2	S	m/s	1e-2	North Velocity
4	2	S	m/s	1e-2	Up Velocity

E. ID: 0x50B，DLC=8，XY-axis accelerometers

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	m/s^2	1e-5	X-Acce
4	4	S	m/s^2	1e-5	Y-Acce

F. ID: 0x60B，DLC=8，XY-axis gyro

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	deg/s	1e-5	X-Gyro
4	4	S	deg/s	1e-5	Y-Gyro

G. ID: 0x70B，DLC=8，gyro Z axis and acce Z axis

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	deg/s	1e-5	Z-Gyro
4	4	S	m/s^2	1e-5	Z-Acce

H. ID:0X09B，DLC=6，GPS second time

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	U	Week	1	GPS Week
2	4	U	Ms	1	GPS Millisecond

I. ID: 0x21B，DLC=8，GNSS latitude and longitude

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	4	S	Degrees	1e-7	Lat
4	4	S	Degrees	1e-7	Lon

J. ID: 0x41B，DLC=6，GNSS three-way velocity

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	S	m/s	1e-2	East Velocity
2	2	S	m/s	1e-2	North Velocity
4	2	S	m/s	1e-2	Up Velocity

K. ID: 0x31B，DLC=5，GNSS height and heading state

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description

0	4	S	m	1e-3	Alt
4	1	U	NULL	1	Flag（Invalid:0;valid：1）

L. ID: 0X51B，DLC=4，GNSS three-axis attitude, heading, pitch

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	U	Degrees	1e-2	heading
2	2				reserved

M. ID:0X61B，DLC=6，three-axis attitude standard deviation, heading standard deviation, pitch standard deviation, roll standard deviation

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	U	Degree	1e-2	heading standard deviation
2	2	S	Degree	1e-2	pitch standard deviation
4	2	S	Degree	1e-2	roll standard deviation

N. ID: 0x71B，DLC=8，latitude and high standard deviation

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	S	m	1e-2	Latitude standard deviation
2	2	S	m	1e-2	The longitude standard deviation
4	4	S	m	1e-3	Highly standard deviation

O. ID: 0x07B，DLC=7，standard deviation of three-way velocity and combined navigation status

Offset(bytes)	Length(bytes)	Type	Units	Factor	Description
0	2	S	m/s	1e-2	East speed standard deviation
2	2	S	m/s	1e-2	Northern speed standard deviation
4	2	S	m/s	1e-2	Standard deviation of day speed
6	1	U char	-	1	Combined navigation

					status Alignment: 1 Navigation: 3

Table 20 Navigation status word

Order number	Type declaration	Corresponding sign	Corresponding ASCII
1	Invalid positioning	0	NONE
2	Single point solution	1	INS_PSRSP
3	Differential positioning	2	INS_PSRDIFF
4	RTK fixed solution	4	INS_RTKFIXED
5	RTK floating point solution	5	INS_RTKFLOAT
6	Recursion	6	INS_SBAS

Table 21 The protocol frequency control table

	The CAN protocol ID No	Frequency
GNSS	0x21B、0x31B 、0x41B、0x51B	1、5、10Hz
INSPVA	0x10B、0x20B、0x30B、0x40B、0x61B、0x71B、0x07B	1、5、10、20、25、50、100、200Hz
TIME	0x09B	1、5、10、20、25、50、100、200Hz
RAWIMU	0x50B、0x60B、0x70B	1、5、10、20、25、50、100、200Hz

Appendix A. GNSS Board Configuration

The GNSS board will be automatically configured by the system and cannot be changed arbitrarily. If the board's baud rate is inadvertently altered, resulting in the combined navigation and the board being unable to connect, please perform a FREST operation on the board via GNSS_COM1 and then restart the system.

Appendix B. CRC reference routine

32-bit CRC reference routine is as follows:

```
#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 );
}
```

example:

A piece of INSPVX data output by BS-IL622-M-D6EC:

0xAA,0x44,0x12,0x1C,0xB9,0x05,0x00,0xA0,0x7E,0x00,0x00,0x00,0x00,0xB4,0x9B,0x08,
0xFE,0xE0,0x9A,0x0D,0x00,0x00,0x00,0x00,0xEB,0x46,0x1A,0x41,0x01,0x00,0x00,0x00,
0x34,0x00,0x00,0x00,0x95,0xE2,0xEF,0x2F,0x1B,0x0A,0x44,0x40,0xCE,0x50,0x5A,0x82,
0x23,0x0F,0x5D,0x40,0x5F,0xCF,0x5C,0x4F,0x9C,0xCD,0x50,0x40,0x48,0x7F,0x16,0xC1,
0xB8,0xE1,0x4C,0x8A,0x1F,0x81,0x8D,0xBF,0xA7,0x23,0x45,0xCA,0x03,0x37,0x78,0x3F,
0xBB,0xC4,0xE7,0x34,0x05,0x05,0x98,0x3F,0x55,0x5A,0x9E,0xD6,0x47,0xE9,0x65,0x40,
0x0F,0x93,0x22,0x60,0xEA,0x0A,0x20,0x40,0x84,0xC4,0x15,0xE2,0x03,0x5B,0xC6,0x3F,
0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,
0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,
0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,**0xAA,0x5E,0x82,0x30**

Where the bold display data is a 32-bit checksum of 0x30825EAA

32-bit CRC Calculation:

```
#include"stdio.h"
void main()
{
    unsigned char buffer[] = {
        0xAA,0x44,0x12,0x1C,0xB9,0x05,0x00,0xA0,0x7E,0x00,0x00,0x00,0x00,0xB4,0x9B,0x08,
        0xFE,0xE0,0x9A,0x0D,0x00,0x00,0x00,0x00,0xEB,0x46,0x1A,0x41,0x01,0x00,0x00,0x00,
        0x34,0x00,0x00,0x00,0x95,0xE2,0xEF,0x2F,0x1B,0x0A,0x44,0x40,0xCE,0x50,0x5A,0x82,
        0x23,0x0F,0x5D,0x40,0x5F,0xCF,0x5C,0x4F,0x9C,0xCD,0x50,0x40,0x48,0x7F,0x16,0xC1,
        0xB8,0xE1,0x4C,0x8A,0x1F,0x81,0x8D,0xBF,0xA7,0x23,0x45,0xCA,0x03,0x37,0x78,0x3F,
        0xBB,0xC4,0xE7,0x34,0x05,0x05,0x98,0x3F,0x55,0x5A,0x9E,0xD6,0x47,0xE9,0x65,0x40,
        0x0F,0x93,0x22,0x60,0xEA,0x0A,0x20,0x40,0x84,0xC4,0x15,0xE2,0x03,0x5B,0xC6,0x3F,
        0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,
        0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,
        0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0xAA,0x5E,0x82,0x30 };

    unsigned long CRC = CalculateBlockCRC32(sizeof(buffer)-4, buffer);//-4 is minus CRC length

    printf("CRC:    %x", CRC);
}
```

Time:132s Almost stright	Device 1				Device 2			
	(UAV config)Dual Ants，RTK，Without odm				(CAR config)Dual Ants，RTK，With odm			
	STDEV	RMS	CEP95	Max δ	STDEV	RMS	CEP95	Max δ
Keep accuracy of Horizontal positioning(m)	31.64	44.88	92.27	120.77	2.53	4.08	7.95	8.92
Keep Distance(m)	3151.84				3135.69			
Average Vehicle Speed (km/h)	81.55				84.7			
Ratio of Horizontal Position Error to Distance （%)	1.04	1.424	2.927	3.832	0.081	0.13	0.254	0.284
Horizontal Radial Error (m)	24.11	34.49	70.8	91.8	1.57	2.44	4.98	5.43
Horizontal Lateral Error(m)	20.54	28.76	59.38	78.65	2.01	3.29	6.22	7.09
Horizontal Velocity Error (m/s)	0.72	1.14	2.28	2.94	0.04	0.08	0.14	0.19
Vertical Velocity Error (m/s)	0.03	0.04	0.09	0.15	0.03	0.03	0.06	0.08
Roll Error (deg)	0.02	0.02	0.04	0.08	0.02	0.12	0.16	0.19
Pitch Error (deg)	0.07	0.25	0.35	0.47	0.02	0.08	0.12	0.18
Heading Error(deg)	0.06	1.13	1.23	1.25	0.08	1.38	1.5	1.53
Hight Error(m)	1.24	1.67	3.78	5.07	0.77	1.53	2.35	2.47