MEMS Inertial Navigation System V 1.0

# BS-MN100A-M-D6EC



## Product characteristics

- 0.2 ° roll & pitch attitude accuracy
- 0.1 ° azimuth accuracy (2m antenna baseline)
- 2 °/H gyro bias stability (Allan)
- 30 μg acceleration bias stability (Allan)

## Field of application

- UAVNavigation
- hicle & Robot Navigation
- / &ROV

## 1-General

BS-MN100A-M-D6EC integrated navigation system (hereinafter referred to as integrated navigation system) has built-in high-performance MEMS gyroscope and accelerometer, which can receive internal GNSS data, realize multi-sensor fusion and integrated navigation solution algorithm, and have 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.

## 2-Functions and indicators

### 2.1 Main functions

The integrated navigation system can use the satellite navigation information received internally to carry out integrated navigation, and output the pitch, roll, course, position, speed, time and other information of the carrier; after losing the satellite signal, the integrated navigation system can output the position, speed and attitude information calculated by the inertial system, and has a certain navigation accuracy maintenance function in a short time.

### 2.2 Performance indicators

The performance of integrated navigation system is shown in Table 1.

Table 1 System Performance Index

| Project | | Metrics (RMS) | Remark |
|---|---|---|---|
| Heading | | | |
| | Dual GNSS | 0.1° | 2m baseline |
| | Single GNSS | 0.2° | Need to maneuver |
| | Post-processing | 0.03° | Optional |
| | Maintain accuracy | 0.2°/min | GNSS failure |
| Attitude accuracy | | | |
| | GNSS is valid | 0.1° | Single-point L1/L2, RTK |
| | Inertial/odometer combination | 0.1° | Optional |
| | Post-processing | 0.02° | Optional |
| | Maintain accuracy | 0.2°/min | GNSS failure |
| | V-G mode | 2° | GNSS failure time unlimited, no acceleration |
| Horizontal positioning accuracy | | | |
| | GNSS is valid | 1.2m | Single-point L1/L2 |
| | | 2cm+1ppm | RTK |

| Project | Metrics (RMS) | Remark |
|---|---|---|
| Inertial/odometer combination | 2 ‰ D (D represents mileage, CEP) | Optional |
| Post-processing | 1cm+1ppm | Optional |
| GNSS failure | 20m | Fail for 60s |
| Horizontal velocity accuracy | | |
| GNSS is valid | 0.1m/s | Single-point L1/L2, RTK |
| Inertial/odometer combination | 0.1m/s（RM S） | Optional |
| Inertial/DVL combination | 0.2m/s（RM S） | Optional |
| Gyroscope | | |
| Measuring range | ±450°/s | |
| Zero bias stability | 2°/h | Allan variance |
| Accelerometer | | |
| Measuring range | ±16g | Customizable 200 G |
| Zero bias stability | 30μg | Allan variance |
| Satellite card | | |
| Cold start | 30 seconds | Open environment |
| Hot start | 5 seconds | Open environment |
| Type of receiver | BDS B1I/B2I/B3I<br>GPS L1C/A/L2P (Y)/L2C/L5<br>GLONASS G1/G2<br>Galileo E1/E5a/E5b<br>QZSS L1/L2/L5 | |
| Communication interface | | |
| RS232 | Route 2 | |
| RS422 | Route 1 | |
| CAN | Route 1 | Optional |
| Odometer differential input | Route 1 | Optional |
| PPS output | Route 1 | Optional |
| Electrical characteristics | | |
| Voltage | 12~36VDC | |
| Power consumption | ≤3W | |

| Project | Metrics (RMS) | Remark |
|---|---|---|
| Ripple | 100 mV | P-P |
| Structural characteristics | | |
| Size | 80 mm×53 mm×23mm | |
| Weight | ≤150g | |
| Use environment | | |
| Operating temperature | -40℃~+60℃ | |
| Storage temperature | -45℃~+65℃ | |
| Vibration | 20~2000Hz，6.06g | |
| Impact | 30g，11ms | |
| Degree of protection | IP65 | |
| Reliability | | |
| MTBF | 30000h | |
| Life span | > 15 years | |
| Continuous working time | >24h | |

## 3. Working principle

### 3.1 Product composition

The composition of the product is shown in Figure 1.

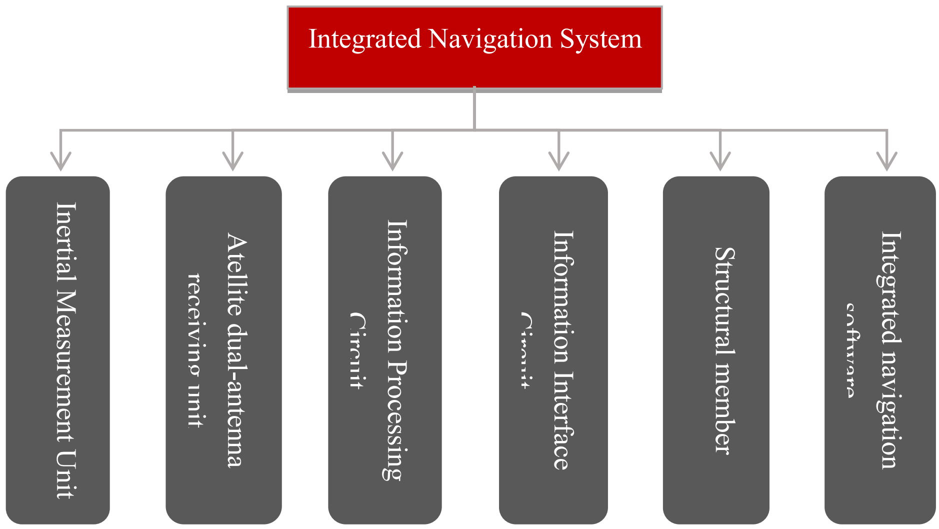


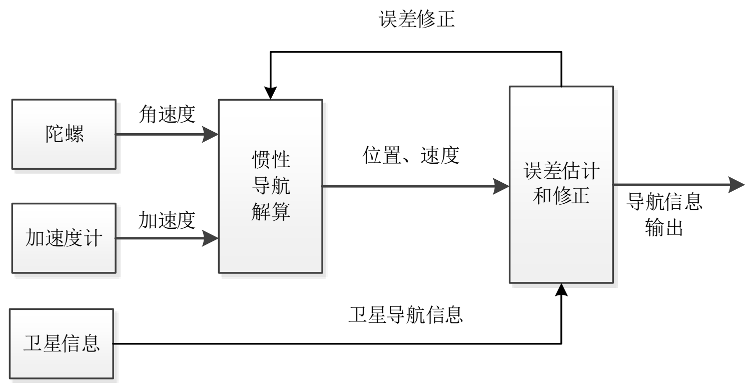

Figure 1 System composition

### 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 of a 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 inertial measurement unit and GNSS receiver adopt an integrated design scheme and are integrated in the integrated navigation system. The system outline is shown in Figure 3.

Overall dimension of integrated navigation system: 80mm × 53mm × 23mm (length × width × height).

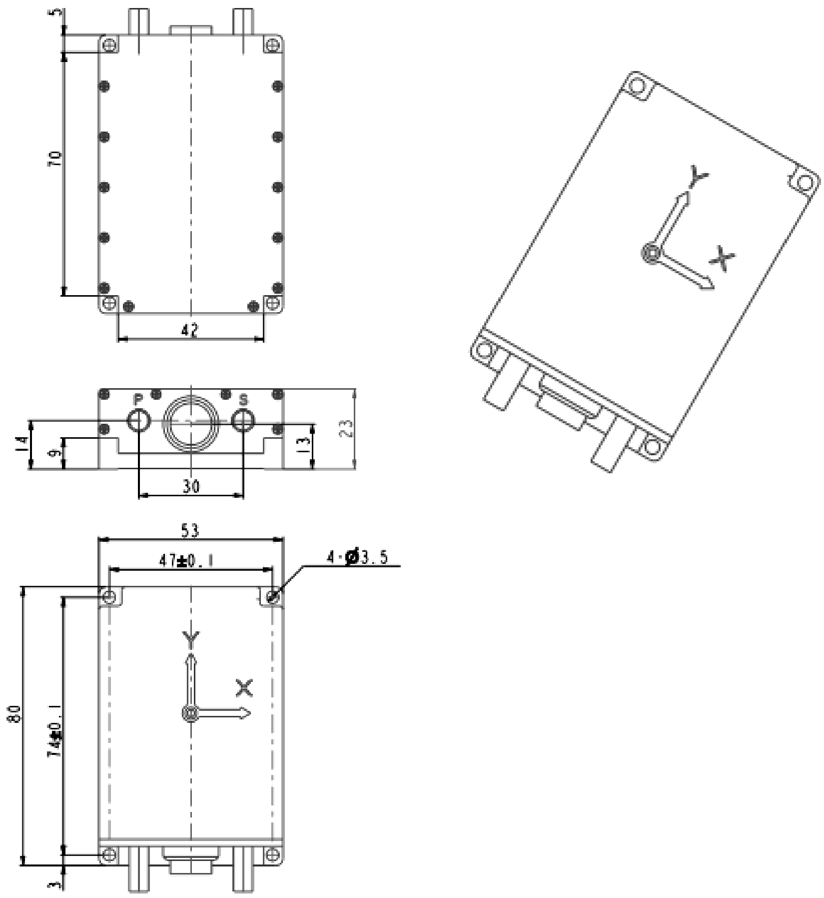



Fig. 3 Outline structure of integrated navigation system

**4.2 Electrical interface**

**4.2.1 product interface**

The system has 3 external connectors:

A power supply and communication interface, whose contact sequence is defined as shown in Figure 4;

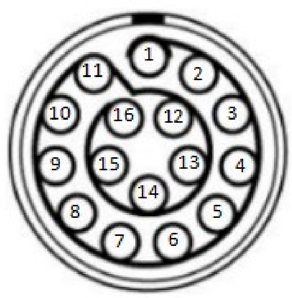



Fig. 4 Power supply and communication interface point number of integrated navigation system (product socket and welding surface)

Two RF line interfaces (SMA outer screw and inner hole), in which the mark P is connected to the main antenna (rear antenna), and the mark S is connected to the slave antenna (front antenna).

**4.2.2 communication cable**

One end of the communication cable is a circular connector to connect the system, and the other end

is divided into a power line and a communication line (the length of the line is 1m):
Power cable: connected to 12 ~ 36 V DC, with external cable, and connected to red and black clips.
Communication cable: with 3 serial ports. COM1 is used to send the working mode command and protocol output, which is RS232; COM2 is the protocol output interface, which is RS422; COM3 is the direct connection port of satellite conductor, which is RS232.
Two RF cables: one end is connected to the antenna, and the other end is connected to the product.
The definition of cable connector contact sequence is shown in Figure 5, and the definition of cable wiring is shown in Table 2.

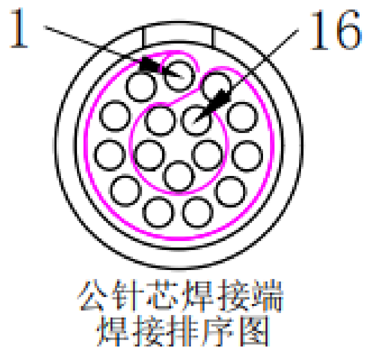



Fig. 5 Distribution of cable connector points (plug and welding surface)

Table 2 Connector Point Definition

| Product butting | | Connection Point 2 | | Terminal number definition (connection point 1) | Length |
|---|---|---|---|---|---|
| Plug wire code | Terminal number | Plug wire code | Terminal number | | |
| P1 | 3 | DB9 female (COM 2) | 3 | COM2_RS422T_P | 1 meter |
| P1 | 4 | | 4 | COM2_RS422T_N | |
| P1 | 1 | | 1 | COM2_RS422R_P | |
| P1 | 2 | | 2 | COM2_RS422R_N | |
| P1 | 9 | | 5 | GND | |
| P1 | 5 | DB9 female (COM 1) | 2 | COM1_RS232T | |
| P1 | 6 | | 3 | COM1_RS232R | |
| P1 | 9 | | 5 | GND | |
| P1 | 7 | Odometer input | Throw the | DI+ | |
| P1 | 8 | | Throw the | DI- | |
| P1 | 9 | Black alligator | GND | GND | |

| Product butting | | Connection Point 2 | | Terminal number definition (connection point 1) | Length |
|---|---|---|---|---|---|
| Plug wire code | Terminal number | Plug wire code | Terminal number | | |
| P1 | 10 | Red alligator clip, large | VCC_IN | VCC_IN | |
| P1 | 11 | CAN interface | Throw the line | CAN_H | |
| P1 | 12 | | Throw the line | CAN_L | |
| P1 | 13 | DB9 Female (GNSS _ COM1) | 2 | GNSS_COM1_T | |
| P1 | 14 | | 3 | GNSS_COM1_R | |
| P1 | 9 | | 5 | GND | |
| P1 | 15 | Differential PPS | Throw the line | PPS+ | |
| P1 | 16 | | Throw the line | PPS- | |

### 4.3 Instructions for use

#### Workflow of 4.3.1 system

After the system is started, it automatically enters the integrated navigation mode without any command control.

#### 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; 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 integrated navigation state, otherwise, the system keeps the coarse alignment state; and when the system is in the integrated navigation state, the integrated navigation system can move.

#### The 4.3.1.2 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 distribution and relevant configuration of each serial port are shown in Table 3.

Table 3 Serial port function distribution of integrated navigation system

| String slogans | Enter the project | Output items | Default |
|---|---|---|---|
| COM1 | 1. working mode | 1.inspvasa、bdfpd、bdfpdb、bdfpdl、gpfpd | 256000bps； |

| String slogans | Enter the project | Output items | Default |
|---|---|---|---|
| | instruction and flow control instruction;<br>2. COM1 ~ COM2 baud rate, protocol and update rate configuration. | 、INStest( 0.2Hz、1Hz、5Hz、10Hz、100 Hz… 200Hz, etc.);<br>2.rawimusb、rawdata、INSpost( 200Hz) ;<br>3. Configuration prompt information。 | Output: bdfpdl 1Hz; |
| COM2 | None | Same as item 1-2 in COM 1 | 460800bps Output: INSpost |

After the system is powered on and the start prompt message 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; updataTime represents the update time, which can be the period of 5 (2 Hz), 1 (1 Hz), 0.2 (5 Hz), 0.1 (10 Hz), 0.01 (100 Hz), etc., 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 disable 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 | Data protocol | Type of agreement | Output type | Support interface |
|---|---|---|---|---|
| | gpfpd | ASCII | ontime | COM1-COM2 |
| | bdfpd | ASCII | ontime | COM1-COM2 |
| | bdfpdb | Binary | ontime | COM1-COM2 |
| | rawimusb | Binary | onchanged | COM1-COM2 |
| | inspvasa | ASCII | ontime | COM1-COM2 |
| | rawdata | Binary | onchanged | COM1-COM2 |
| | 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 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 |
|---|---|---|---|---|
| | $GPFPD | Format header | — | — |
| | GPSWeek | Current week number (GMT) since January 6, 1980 | Integer | — |
| | GPS cycles per second | GPS cycles per second | Floating-point type | s |
| | Yaw Angle | Yaw 0 ~ 360 degrees, clockwise | Floating-point type | Degree |
| | Pitch Angle | Pitch angle -90 ° ~ 90 ° | Floating-point type | Degree |
| | Roll Angle | Roll angle -180 ° ~ 180 ° | Floating-point type | Degree |
| | Latitude | Combined Output Latitude -90 ° ~ 90 ° | Floating-point type | Degree |
| | Longitude | Combined output longitude -180 ° ~ 180 ° | Floating-point type | Degree |
| | Height | Height of the combined output | Floating-point type | m |
| | East speed | Combined output east speed | Floating-point type | m/s |
| | North speed | Combined output north speed | Floating-point type | m/s |
| | Sky speed | Combined output speed | Floating-point type | m/s |
| | Baseline length | Distance between centers of two satellite antenna | Integer | Meters |
| | NSV1 | Number of satellites for antenna 1 | Integer | A |
| | NSV2 | Number of satellites for antenna 2 | Integer | A |
| | Satellite status | Satellite status 0: unavailable, 1: available | Integer | — |
| | Check code | Check code (value after exclusive or of number between $and *) | Hexadecimal | — |
| | <CR><LF> | Fix the tail of the package | — | — |

**Table 6 bdfpd format**

| Serial number | Name | Meaning | Data type | Unit |
|---|---|---|---|---|
| | $BDFPD | Format header | — | — |
| | GPSWeek | Current week number (GMT) since January 6, 1980 | Integer | — |
| | GPS cycles per second | GPS cycles per second | Floating-point type | s |
| | Yaw Angle | Yaw 0 ~ 360 degrees, clockwise | Floating-point type | Degree |
| | Pitch Angle | Pitch angle -90 ° ~ 90 ° | Floating-point type | Degree |
| | Roll Angle | Roll angle -180 ° ~ 180 ° | Floating-point type | Degree |
| | Latitude | Combined Output Latitude -90 ° ~ 90 ° | Floating-point type | Degree |
| | Longitude | Combined output longitude -180 ° ~ 180 ° | Floating-point type | Degree |
| | Height | Height of the combined output | Floating-point type | m |
| | East speed | Combined output east speed | Floating-point type | m/s |
| | North speed | Combined output north speed | Floating-point type | m/s |
| | Sky speed | Combined output speed | Floating-point type | m/s |
| | NSV1 | Number of satellites for antenna 1 | Integer | A |
| | NSV2 | Number of satellites for antenna 2 | Integer | A |
| | Positioning type | Postype in bestpos, see Table 12 | Integer | — |
| | Directional type | Postype in heading, see Table 12 | Integer | — |
| | Check code | Check code (value after exclusive or of number between $and *) | Hexadecimal | — |
| | <CR><LF> | Fix the tail of the package | — | — |

**Table 7 Format of bdfpdl**

| Serial number | Name | Meaning | Data type | Unit |
|---|---|---|---|---|

| Serial number | Name | Meaning | Data type | Unit |
| --- | --- | --- | --- | --- |
| | $BDFPD | Format header | — | — |
| | GPSWeek | Current week number (GMT) since January 6, 1980 | Integer | — |
| | GPS cycles per second | GPS cycles per second | Floating-point type | s |
| | Yaw Angle | Yaw 0 ~ 360 degrees, clockwise | Floating-point type | Degree |
| | Pitch Angle | Pitch angle -90 ° ~ 90 ° | Floating-point type | Degree |
| | Roll Angle | Roll angle -180 ° ~ 180 ° | Floating-point type | Degree |
| | Latitude | Combined Output Latitude -90 ° ~ 90 ° | Floating-point type | Degree |
| | Longitude | Combined output longitude -180 ° ~ 180 ° | Floating-point type | Degree |
| | Height | Height of the combined output | Floating-point type | m |
| | East speed | Combined output east speed | Floating-point type | m/s |
| | North speed | Combined output north speed | Floating-point type | m/s |
| | Sky speed | Combined output speed | Floating-point type | m/s |
| | X-axis angular rate | IMU is on the right | Floating-point type | °/s |
| | Y-axis angular rate | Before the IMU system | Floating-point type | °/s |
| | Z-axis angular rate | Attach the IMU | Floating-point type | °/s |
| | X-axis acceleration | IMU is on the right | Floating-point type | m/s2 |
| | Y-axis acceleration | Before the IMU system | Floating-point type | m/s2 |
| | Z-axis acceleration | Attach the IMU | Floating-point type | m/s2 |
| | NSV1 | Number of satellites for antenna 1 | Integer | A |
| | NSV2 | Number of satellites for antenna 2 | Integer | A |
| | Positioning type | Postype in bestpos, see Table 12 | Integer | — |

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

**Table 8 Format of inspvasa**

| Serial number | Name | Meaning | Data type | Unit |
| --- | --- | --- | --- | --- |
| | %INSPVASA | Format header | — | — |
| | GPSWeek | Current week number (GMT) since January 6, 1980 | Integer | — |
| | GPS cycles per second | GPS cycles per second | Floating-point type | s |
| | GPSWeek | Current week number (GMT) since January 6, 1980 | Integer | — |
| | GPS cycles per second | GPS cycles per second | Floating point number | s |
| | Latitude | Combined Output Latitude -90 ° ~ 90 ° | Floating-point type | Degree |
| | Longitude | Combined output longitude -180 ° ~ 180 ° | Floating-point type | Degree |
| | Height | Height of the combined output | Floating-point type | m |
| | North speed | Combined output north speed | Floating-point type | m/s |
| | East speed | Combined output east speed | Floating-point type | m/s |
| | Sky speed | Combined output speed | Floating-point type | m/s |
| | Roll Angle | Roll angle -180 ° ~ 180 ° | Floating-point type | Degree |

| Serial number | Name | Meaning | Data type | Unit |
|---|---|---|---|---|
| | Pitch Angle | Pitch angle -90 ° ~ 90 ° | Floating-point type | Degree |
| | Yaw Angle | Yaw 0 ~ 360 degrees, clockwise | Floating-point type | Degree |
| | INS status | See Table 11 | — | — |
| | Check code | Check code (number between% and * 32-bit CRC check) | Hexadecimal | — |
| | <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 | — | |
| 2 | 4 | Message length | 0x3c | — | |
| 3 | 5-8 | Week of GNSS | Current week number (GMT) since January 6, 1980 | 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 | — |

| Serial number | Number of bytes | Definition | Meaning | Data type | Remark |
|---|---|---|---|---|---|
| 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 12 | unsigned short | — |
| 17 | 63-64 | Directional type | Postype in heading, see Table 12 | unsigned short | — |
| 18 | 65-68 | Checksum | 5-64 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 | | 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 | |

| Serial number | Number of bytes | Definition | Meaning | Data type | Remark |
|---|---|---|---|---|---|
| 8 | 25-28 | IMU status word | See Table 13 | 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 11 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 12 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 |

| Type numeric value | Type definition | Type description |
|---|---|---|
| 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 13 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 | |
| 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.

```c
#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, the configuration command is:

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:

possmooth switch

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:

setimutoantoffset armXarmyarmZ

The slave antenna configuration instructions are as follows:

setimutoantoffset2 armXarmyarmZ

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 6, armX and armY should be negative, and armZ should be positive.

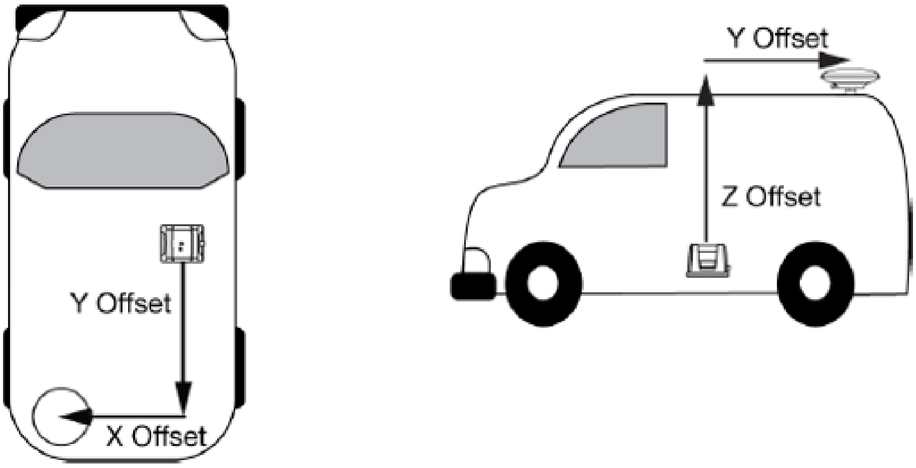



Figure 6 Schematic diagram of antenna rod arm

**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:

setimutosensoroffset armXarmyarmZ

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 7, armY and armZ should be positive.

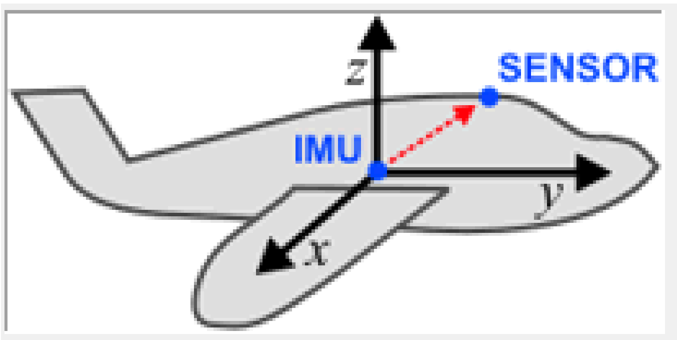



Fig. 7 Schematic diagram of output lever arm

**Setting of mounting angle of 4.3.2.10**

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 is considered to coincide with the installation carrier coordinate system. 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:
vehiclebodyrotation angleX 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.

#### 4.3.2.11 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

### 4.3.3 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 "100 …" 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.

## 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

### Description of the differential configuration of the 6.1

The integrated navigation system can receive the differential correction information sent by the reference station through the communication link, work in the differential state, and achieve the positioning accuracy of centimeter level. Differential configuration mainly includes three parts: 1. Reference station setting; 2. Communication link setting; 3. Mobile station setting. The data link is shown in the following illustration.

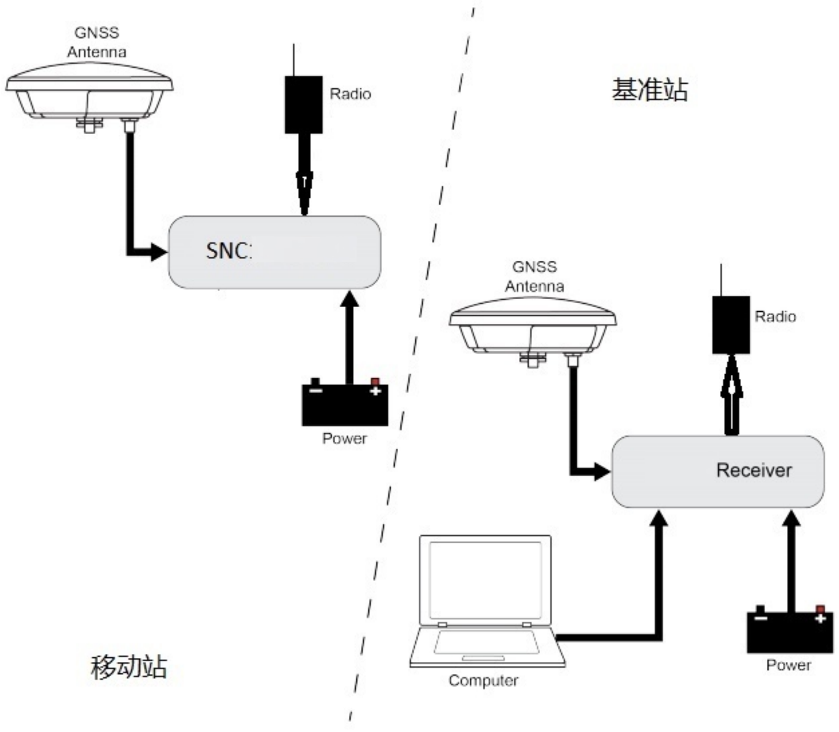



Figure 8 Data Link Diagram

### Setting of 6.1.1 reference station

The differential reference station is the satellite receiver with the antenna of the satellite receiver installed in a fixed position. During the use of the satellite receiver, it is necessary to ensure that the antenna is fixed. In the working process of the differential reference station, the precise coordinates of the fixed position and the received satellite information are sent to the mobile station (the point to be positioned) through the communication link, which is used for the mobile station to carry out differential positioning calculation, realize differential high-precision positioning, and achieve centimeter-level positioning accuracy.

The NovAtel-718D satellite receiver card can be applied to the reference station, and it can be configured as the reference station mode. The specific configuration instructions are as follows. See the NovAtel-718D user manual for details.

Table 14 Reference Station Configuration Instructions

| Serial number | Instruction | Explain |
|---|---|---|
| 1 | fix position39.8122 116.1515 60.5 | Set the known precise coordinates (latitude 39.8122, 经度 116.1515, altitude 60.5) as the reference station coordinate values |
| | posaveon 0.01 1.5 2.5 | When the receiver autonomously positions 0.01 H, or the standard deviation of horizontal positioning is less than or equal to 1.5m, and the standard deviation of height positioning is less than or equal to 2.5m, the average value of positioning is taken as the coordinate value of the reference station |
| 2 | serialconfig com1 9600 | Set the output baud rate of the output interface COM1 of the reference station to 9600 bps |
| 3 | interfacemode com1 novatel rtcmv3 on | Configure COM1 input data type as novatel, output data type as rtcmv3, and enable command feedback |
| 4 | log com1rtcm1075ontime 1 | GPS differential message |
| 5 | log com1rtcm1125ontime 1 | BDS differential message |
| 6 | log com1rtcm1085ontime 1 | GLO differential message |
| 7 | log com1rtcm1033ontime 10 | Description of receiver and antenna |
| 8 | log com1rtcm1005ontime 10 | Antenna reference point coordinates of RTK reference station |
| 9 | saveconfig | Save the configuration |

### 6.1.2 communication link settings

The communication link can use 4G DTU or data radio, and the coverage of 4G DTU is the coverage of network information; subject to national laws, the coverage of data radio is about 10 km. For the setting of 4G DTU and digital radio, please refer to the user manual of the corresponding product.

### 6.1.3 mobile station settings

The integrated navigation system is a differential mobile station. The mobile station receives the differential correction information of the reference station in real time, and receives the satellite signal to calculate the differential positioning, so as to realize the differential high-precision positioning. The integrated navigation system supports RTCM and RTCMV3 standard data protocols. COM2 of the integrated navigation system can be configured as the receiving interface of differential correction information, and the specific configuration instructions are as follows.

Table 15 Mobile station configuration command

| Serial number | Instruction | Explain |
|---|---|---|
| 1 | com com2 X | The input baud rate of the mobile station input interface COM2 is set to Xbps according to the differential input data baud rate |
| 2 | saveconfig | Save the configuration |

## 7. Update records

| **Serial number** | **Version** | **Change the date** | **Before the change** | **After the change** | **Reason for the change** | **Changed by** |
|---|---|---|---|---|---|---|
| 1 | V1.00 | 20230307 | | V3 version | New | YHS |