



1 Features

Hardware

- Up to 8 arrays of high-performance IMUs
- Factory -40-85°C full temperature compensation, calibration scale factor, cross-axis, zero bias
- The gyroscope bias instability is down to 1.2 °/h
- Accelerometer bias instability is down to 0.014mg
- RS-232/UART(TTL)/RS-485/CAN
- Support PPS, synchronous input, synchronous output signal
- Working voltage range: 5-48V (CAN 7-48V).
- IP68 waterproof
- Integrated temperature sensor
- M12 aircraft plug-in interface
- Small size, easy to install
- RoHS, CE Cert.

Software

- Extended Kalman fusion algorithm with up to 1000Hz output and low latency
- Excellent dynamic following performance and good vibration suppression
- It has excellent suppression of linear acceleration
- Startup time<1s
- Support CANopen, Modbus, binary and other protocols
- No external command configuration is required and data is output directly
- Abundant user configuration instructions
- Multi-function GUI for easy operation
- Supports ROS, C, QT, etc

2 Application

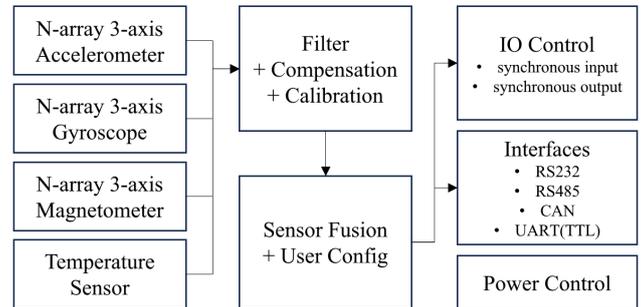
- Precision instrumentation
- Platform stability and control
- Construction machinery
- Underground instrumentation
- Robot

3 Description

Product Appearance



System Block Diagram



General Description

The HI14 series are IMU/VRU/AHRS sensors composed of array MEMS-IMU and magnetometer, and is equipped with self-developed extended Kalman filter, IMU noise dynamic analysis algorithm, and carrier motion state analysis algorithm, which can meet the accuracy of attitude angle under high dynamic and reduce the drift of course angle.

Each sensor is finely compensated before leaving the factory, including temperature, bias, scale factor, and cross-axis.

The HI14 series sensors transmit data through UART (RS-232/TTL), RS-485, CAN, USB and other interfaces, and have rich user configurations

The HI14 series can be synchronized with the system via external triggers (PPS or sync pulses) and can also be time-aligned with external systems such as radar and cameras via the sync output function.

The multi-function host computer (GUI) can help to quickly evaluate the product, including but not limited to module configuration, data display, firmware upgrade, data logging, etc. For selection and ordering information, please refer to [Table 1](#), [Table 2](#).

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4 Product selection

Table1. Selection

| Product | HI14a-b-c ¹ | | | |
|---------|------------------------|-------------------|-----|-----------------------------------|
| | a- Sensor | b- Data interface | | c- Synchronization function |
| HI14 | R3 | 4XIMU+Magnetic | 232 | RS-232 |
| | R5 | 8XIMU+ Magnetic | 485 | RS-485 |
| | | | CAN | CAN2.0 |
| | | | URT | UART(TTL) |
| | | | USB | USB2 |
| | | | | 000 No sync function |
| | | | | 100 With synchronization function |

Note1. Example: HI14R5-232-000, all types are acquiesced to be fully warm

5 Ordering Information

Table2. Ordering Information

| Interface | Part Number | Name | Description |
|-----------|----------------|---------------------------|--|
| RS-232 | HI14R3-232-100 | 4 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 2.5°/h 30ug M12, with Synchronization |
| | HI14R5-232-100 | 8 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 1.76°/h 21ug M12, with Synchronization |
| UART(TTL) | HI14R3-URT-100 | 4 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 2.5°/h 30ug M12, with Synchronization |
| | HI14R5-URT-100 | 8 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 1.76°/h 21ug M12, with Synchronization |
| RS-485 | HI14R3-485-000 | 4 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 2.5°/h 30ug M12 |
| | HI14R5-485-000 | 8 array IMU/VRU/AHRS/AHRS | 6DoF+Magnetic 1.76°/h 21ug M12 |
| CAN | HI14R3-CAN-000 | 4 array IMU/VRU/AHRS/AHRS | 6DoF 2.5°/h 30ug M12 |
| | HI14R5-CAN-000 | 8 array IMU/VRU/AHRS/AHRS | 6DoF 1.76°/h 21ug M12 |

Note1: Synchronous RS-232 interface is pre-configured with M12 8-pin straight female OPEN DB9 female Cable. The length of the cable is 3m, see Table 21

Note2: The synchronous UART (TTL) interface is equipped with M12 8-core straight female OPEN cable by default, the cable length is 3m

Note3: The RS-485 and CAN interfaces are equipped with M12 5-core straight female OPEN cable by default, the cable length is 3m

Order and inquiry:

Email: sltech@ms28.hinet.net

Tel: +886-02-8969-9610

6 File Information

6.1 Version information

Table3. File version

| version | date | description |
|---------|---------------|----------------------------|
| 00 | April 4, 2024 | Initial release |
| 10 | Jan 1, 2026 | Update hardware parameters |

7 Parameter

If there is no special note, the test temperature is 25°C, the power supply voltage is 24V, the gyroscope range is 2000°/s, the accelerometer range is 12g, the geomagnetic range is 8Gauss, and the test sample is 8Pcs.

7.1 Typical

Table4. Typical

| Parameters | Condition | Product | Min | Type | Max | Unit | Note |
|-----------------------|---------------------------|---------|-----|------|------|------|------|
| Input voltage | RS232 & RS485 & UART(TTL) | | 5 | 24 | 48 | V | 1 |
| | CAN interface | | 7 | 24 | 48 | | |
| power consumption | | HI14R3 | | | <0.4 | In | |
| | | HI14R5 | | | <0.6 | | |
| Operating temperature | | | -40 | - | 85 | °C | |
| Gyroscope range | | | 125 | 2000 | 2000 | °/s | |
| Accelerometric | | | 3 | 12 | 24 | g | |
| Start-up time | | | | | 1 | s | 2 |

Note1. EMC Directive 2014/30/EU, support anti-polar protection, short circuit protection

Note2. Startup time refers to the time from shutdown to effective data output of the system at power-on. The module should be kept stationary during this time

7.2 Absolute maximum

Table5. Absolute maximum

| Parameters | Limit | Unit | Note |
|-----------------------|----------|------|-------------------|
| Mechanical shock | 2000 | g | Duration <1ms |
| Storage temperature | -40-85 | °C | |
| ESD | 30 | KV | JEDEC/ESDA JS-001 |
| Input voltage | 50 | V | |
| IO1 | 0 to 5 | V | |
| IO2 | 0 to 3.3 | V | |
| TXD(TTL) | 0 to 3.3 | V | |
| RXD(TTL) | 0 to 5 | V | |
| RS-232 TX To GND | ±13.2 | V | |
| RS-232 RX To GND | ±24 | V | |
| CAN H or CAN L to GND | ±40 | V | |
| CAN H to CAN L | ±27 | V | |
| RS-485 A or RS-485 B | -8 to 13 | V | |

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7.3 Interface parameters

Table6. Interface parameters

| Interface | Parameters | Condition | Min | Type | Max | Unit | Note |
|-----------|-------------------------------|---------------|------|--------|--------|------|------|
| RS-232 | Serial transfer rate | | 9600 | 115200 | 921600 | bps | 1 |
| | Output frame rate | | 0 | 100 | 1000 | Hz | 2 |
| | Output voltage | | ±5.0 | ±5.4 | | V | |
| | Output impedance | | | 300 | | Ω | |
| | Input voltage | | -15 | | 15 | V | |
| | Input impedance | | | 3 | 5 | 7 | kΩ |
| UART(TTL) | Serial transfer rate | | 9600 | 115200 | 921600 | bps | 1 |
| | Output frame rate | | 0 | 100 | 1000 | Hz | 2 |
| | Output voltage | | | 3.3 | 3.6 | V | |
| | Input voltage | | 0 | 3.3 | 5 | V | |
| RS-485 | Serial transfer rate | | 9600 | 115200 | 115200 | bps | 3 |
| | Output frame rate | | 0 | 10 | 50 | Hz | 4 |
| | Differential output voltage | | 2 | | 5 | V | |
| | Output common-mode voltage | | | 2.5 | 3 | V | |
| | Input impedance | Open | 48 | | | kΩ | |
| | | short circuit | | 120 | | Ω | 5 |
| CAN | Serial transfer rate | | 125 | 500 | 1000 | kbps | 6 |
| | Output frame rate | | 5 | 100 | 200 | Hz | 7 |
| | Differential Exports | | 1.5 | - | 3 | V | |
| | CANH, CANL differential input | Open | 19 | 30 | 52 | kΩ | |
| | resistance | short circuit | | 120 | | Ω | 5 |

Note1. The serial port of the sensor is configured with a start bit of 1bit, a data length of 8bits, a stop bit of 1bit, no verification, and the commonly used serial transmission rates supported are 9600, 115200, 230400, 25600, 460800, and 921600

Note2. The sensor supports 1, 5, 10, 50, 100, 200, 250, 500, 1000Hz data output. 200, 250Hz rate requires serial transmission rate ≥ 230400 , 500Hz rate requires serial transmission rate ≥ 460800 , 1kHz ratio requires serial transmission rate = 921600.

Note3. RS-485 communication supports serial transmission rates of 9600, 115200.

Note4. The sensor supports 5, 10, 50Hz data output for RS-485.

Note5. If you need a 120Ω resistor, it needs to be customized, please contact us before purchasing.

Note6. CAN interface support 125K,250K,500K,1000K

Note7. The sensor supports 5, 10, 50, 100, 200Hz for CAN data output.

7.4 Gyroscope

Table7. Gyroscope parameters

| Parameters | Condition | Product | Min | Type | Max | Unit | Note |
|--|------------------------------------|---------|-------|-------|------|------|------|
| Range | | | | 2000 | | °/s | |
| Resolution | | | | 16bit | | | |
| Scale factor | 100°/s | HI14R3 | | <300 | 350 | ppm | 1 |
| | | HI14R5 | | <300 | 300 | | |
| Nonlinear | (Optimized fit line) Fs=2000°/s | | -0.05 | - | 0.05 | %Fs | 2 |
| 3dB bandwidth | | | 90 | 116 | 200 | Hz | |
| Sampling rate | | | | 1000 | | Hz | |
| Zero bias instability | Allan Variance | HI14R3 | | 1.6 | | °/h | 1σ |
| | | HI14R5 | | 1.2 | | | |
| Zero bias repeatability | Allan Variance | HI14R3 | | 12 | | °/h | 1σ |
| | | HI14R5 | | 8 | | | |
| Angle random walk | Allan Variance | HI14R3 | | 0.25 | | °/√h | 1σ |
| | | HI14R5 | | 0.18 | | | |
| Zero-bias full-temperature variation -40-85°C | | | | 0.07 | 0.2 | °/s | 3 |

Note1. Rotate on the turntable 10 times, and average the measurement

Note2. Maximum deviation from the best-fit straight line within the specified range

Note3. Measured on the laboratory thermostat turntable, the temperature rise slope is less than 5°C/min

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7.5 Accelerometer

Table8. Accelerometer parameters

| Parameters | Condition | Product | Min | Type | Max | Unit | Note |
|--------------------------------------|-------------------------------|---------|-----|-------|-----|----------------|------------|
| Range | | | | 12 | | g | |
| Resolution | | | | 16bit | | | |
| Initial bias | | | | | 10 | mg | |
| Nonlinear | (Optimized fit line) Fs=3g | | | 0.5 | | %Fs | 1 |
| 3dB bandwidth | | | 80 | 145 | 200 | Hz | |
| Sampling rate | | | | 1600 | | Hz | |
| Zero bias instability | Allan Variance | HI14R3 | | 0.018 | | mg | 1 σ |
| | | HI14R5 | | 0.014 | | | |
| Zero bias repeatability | Allan Variance | HI14R3 | | 0.15 | | mg | 1 σ |
| | | HI14R5 | | 0.1 | | | |
| Random walk | Allan Variance | HI14R3 | | 0.04 | | m/s \sqrt{h} | 1 σ |
| | | HI14R5 | | 0.028 | | | |
| Zero-bias full-temperature variation | -40-85°C | | | 2 | 3 | mg | 1 σ |

Note1. Maximum deviation from the best-fit straight line within the specified range

7.6 Magnetometer

Table9. Magnetometer parameters

| Parameters | Condition | Min | Type | Max | Unit | Note |
|---------------|----------------------------|-----|-------|-----|--------|------|
| Range | | -8 | - | 8 | Gauss | |
| Resolution | Fs=2G | | 2 | | mGauss | |
| Sampling rate | | | 200Hz | | | |
| Linearity | (Optimized fit line) Fs=2G | | 0.1 | | Fs% | |

7.7 Temperature sensors

Table10. Temperature sensor parameters

| Parameters | Condition | Min | Type | Max | Unit | Note |
|------------|-----------|-----|------|-----|------|------|
| Range | | -45 | - | 85 | °C | |
| Zero bias | Fs=2G | | ±1 | | K | |

7.8 Allan Variance

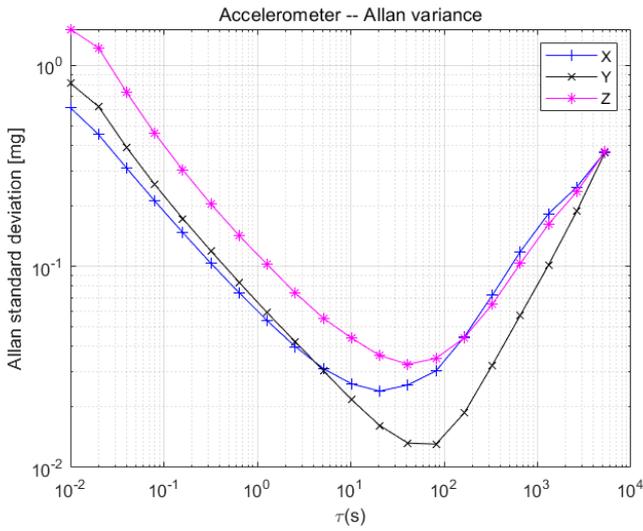


Figure1. HI14R3 Accelerometer Allan Variance

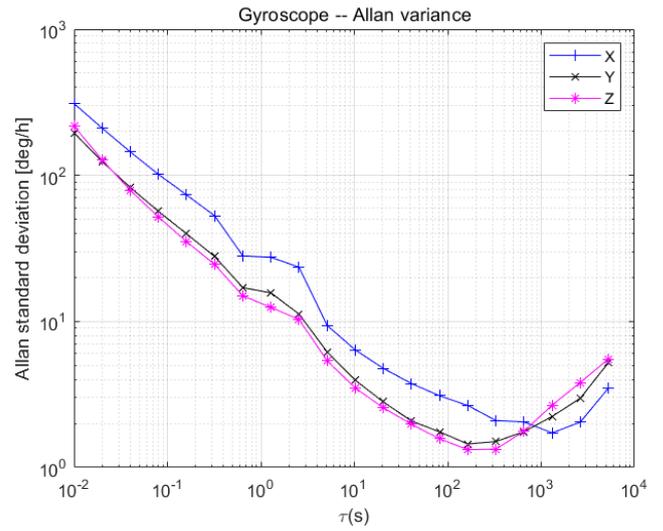


Figure2. HI14R3 Gyroscope Allan Variance

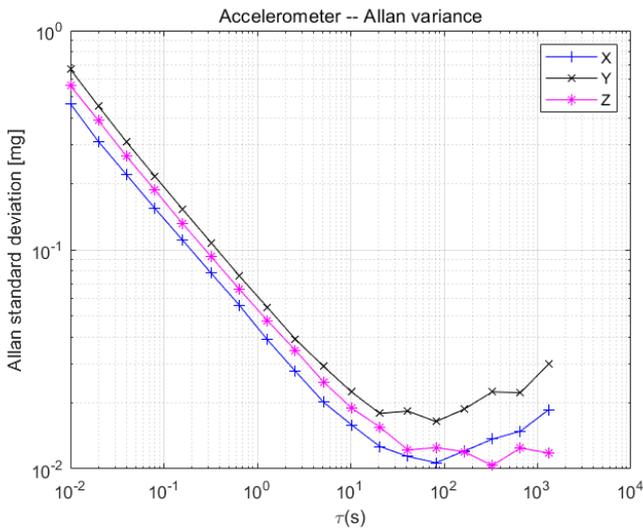


Figure3. HI14R5 Accelerometer Allan Variance

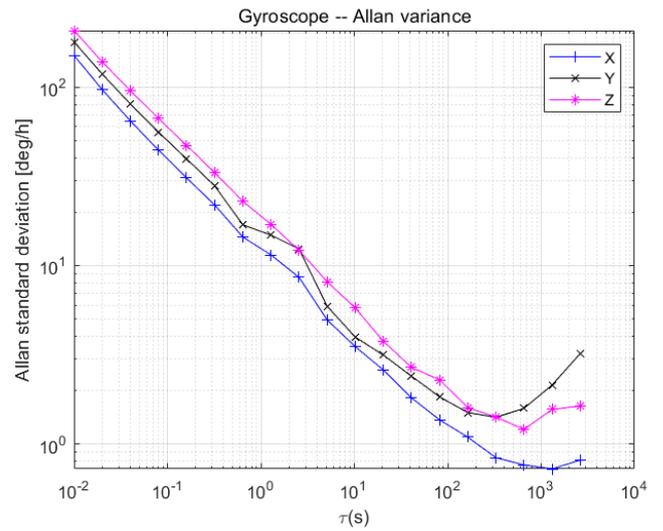


Figure4. HI14R5 Gyroscope Allan Variance

7.9 Temperature-compensated curve

The temperature of the measured sample was raised from -40°C to 85°C , and the bias data of the sample was compensated, and the compensation results are as follows

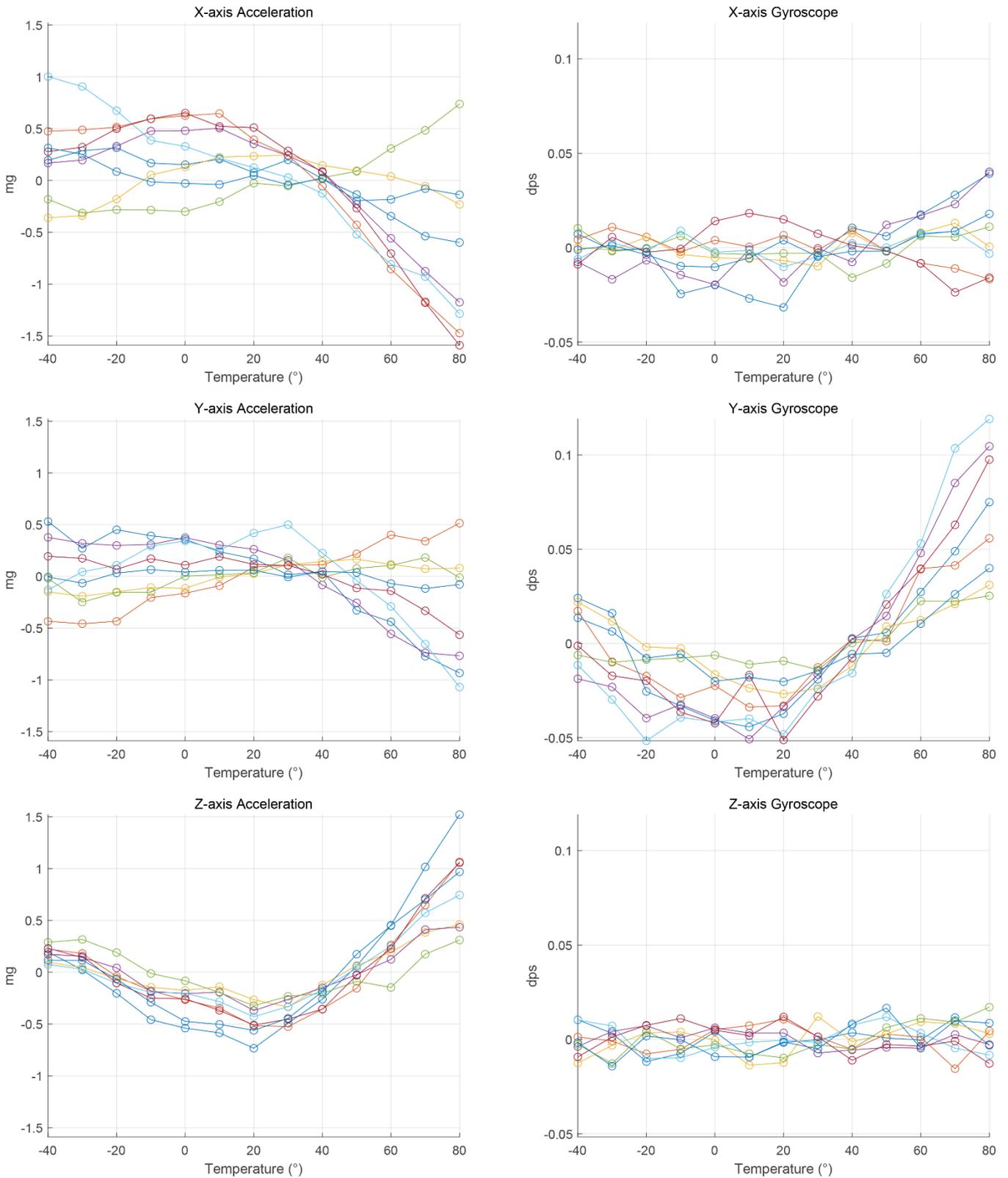


Figure5. Accelerometer and Gyroscope Temperature Compensated Curve

7.10 Fusion parameters

Table11. Fusion parameters

| Parameters | Value |
|----------------------|-------|
| Pitch | ±90° |
| Roll | ±180° |
| Heading angle (Yaw). | ±180° |
| Resolution | 0.01° |

7.11 Attitude angle accuracy

Table12. Attitude angle accuracy

| Parameters | Condition | Product | Min | Type | Max | Unit | Note |
|---|--------------------|------------------|-----|------|----------|------|------|
| Pitch/Roll (static) | | | | 0.15 | 0.2 | ° | |
| Pitch/Roll (Dynamic) | | | | 0.15 | 0.2 | ° | |
| Static drift of heading angle (6DOF) | Stand still for 2h | | | 0.15 | 0.2 | ° | 1 |
| Dynamic drift error of heading angle (6DOF) | | HI14R3 HI14R5 | | 5 | 15 | ° | 2 |
| Dynamic drift error of heading angle (with geomagnetic assist, 9-axis mode) | | HI14R3 & HI14R5 | | 2 | 3 | ° | 3 |
| Rotation error of heading angle (6DOF) | 100°/s rotation | HI14R3 HI14R5 | | <0.8 | 1.3 1 | ° | 4 |

Note1. Measured when the module is stationary at 25°C for 2 hours

Note2. The module was measured by moving on the indoor cleaning robot for 1 hour. 1σ

Note3. After geomagnetic calibration, the measurement is carried out without magnetic field interference in the surrounding area, and the product needs to be configured to AHRS mode

Note4. The turntable rotates continuously for 10 turns, 100°/s, the cumulative error of the heading angle, room temperature is 25°C

7.12 Mechanical and environmental parameters

Table13. Mechanical and environmental parameters

| Parameters | Value |
|--------------------------|---|
| Size | 58.5X40X20mm |
| Weight | <75g |
| Housing material | Aluminum alloy |
| Set the screws | M3 |
| Surface treatment | Positive Electrode |
| Storage temperature | -50°C-90°C |
| Anti-vibration | 1.0 mm (10 Hz – 58 Hz) & ≤ 20 g (58 Hz to 600 Hz) |
| Waterproof rating | IP68 |
| Environmental protection | RoHS 2011/65/EU |

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7.13 Product dimensions

All Dimensions in mm units.

7.13.1 M12 size

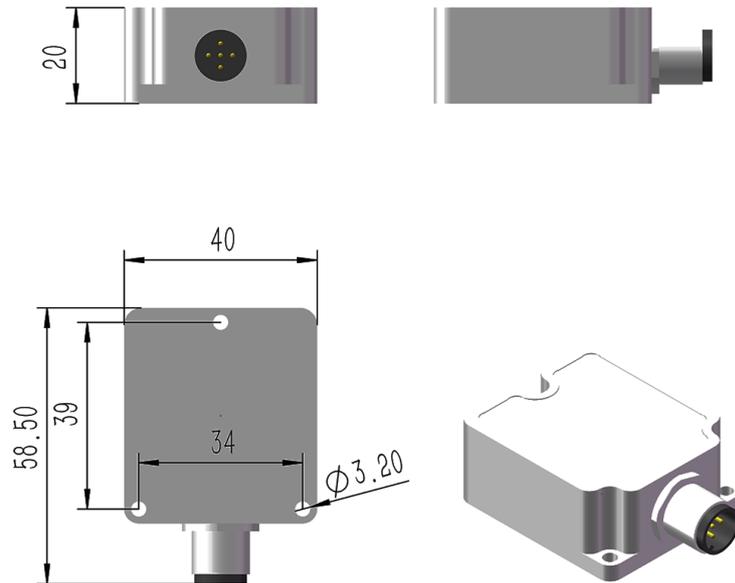


Figure6. HI14 M12 Connector Dimension

7.14 Recommended installation:

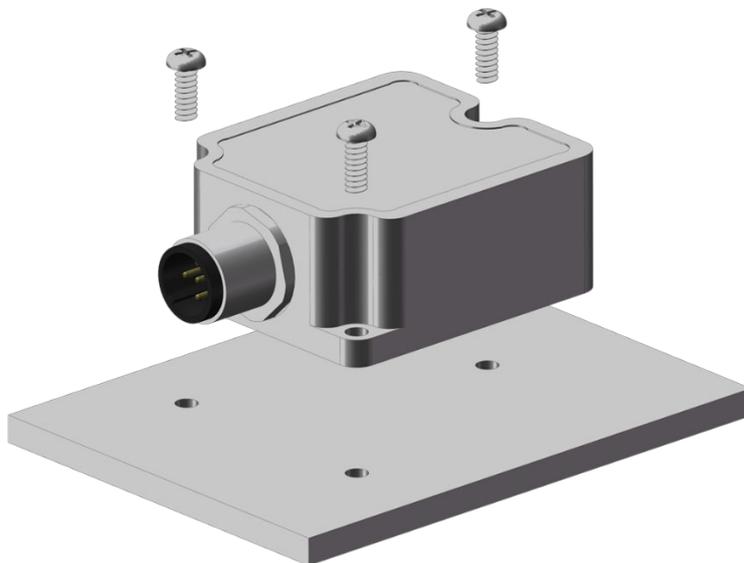


Figure7. Mounting Example

- ✚ For other mounting methods, please refer to the instructions and programming manual for coordinate rotation
- ✚ It is recommended to install it in a location where the carrier has little vibration and little temperature change

8 Coordinate system definition

8.1 coordinate system

The carrier system uses the right-front-upper (RFU) system, and the geographic system uses the eastern-north-day (ENU) system. The acceleration and gyroscope direction are shown in the figure below

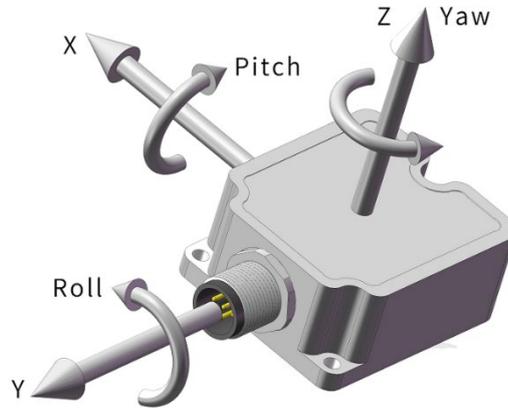


Figure8. HI14 Coordinate System

The rotation order of the Euler angle is east-north-day-312 (first the Z axis, then the X axis, and finally the Y axis). The specific definitions are as follows:

1. Rotation around the Z-axis (Yaw):
 - Yaw angle (ψ) ranges from -180° to 180° .
 - Represents the rotation about the vertical axis (Z-axis).
2. Rotation around the X-axis (Pitch):
 - Pitch angle (θ) ranges from -90° to 90° .
 - Describes the rotation about the lateral axis (X-axis).
3. Rotation around the Y-axis (Roll):
 - Roll angle (ϕ) ranges from -180° to 180° .
 - Corresponds to the rotation about the longitudinal axis (Y-axis).

If the module is an aircraft, the positive direction of the Y axis should be considered as the nose direction. When the sensor frame coincides with the inertial frame, the Euler angle output is :Pitch = 0° , Roll = 0° , Yaw = 0°

8.2 Sensor centroid position

Table14. HI14 family center of mass

| Axis | X-offset | Y-offset | Z-offset | Unit |
|------|----------|----------|----------|------|
| X | 0 | 0 | 6.2 | mm |
| Y | 0 | 0 | 6.2 | mm |
| Z | 0 | 0 | 6.2 | mm |

9 Pin definition

9.1 M12 connector terminal definition

9.1.1 RS232 & UART Interface Definition



Figure9. M12-A Code 8Pin Male of Sensor

Table15. RS232 & UART Pin Description

| M12 gets 8pin | | | | | | | | | |
|---------------|-------------|-------------|-------------|--------------|------------|------------|------------|-----------|--|
| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Color | White (WH). | Brown (BN). | Green (GN). | Yellow (YL). | Gray (GY). | Pink (PK). | Blue (BU). | Red (RD). | |
| Name | SGND | Vs | GND | RXD | TXD | SGND | SIN | SOUT | |

9.1.2 RS232 & UART Pin Description

Table16. RS232 & UART Pin Description

| Number | Name | Type | RS-232 | UART(TTL) |
|--------|------|-------|---|---------------------------------|
| 1 | SGND | Power | Signally | Signal ground |
| 2 | Vs | Power | Power+ | Power+ |
| 3 | GND | Power | Power Supply Locations | Power supply ground |
| 4 | RXD | I | Serial port receives RS-232 level | Serial port receives TTL level |
| 5 | TXD | O | The serial port transmits RS-232 levels | Serial port transmits TTL level |
| 6 | SGND | Power | Signal ground | Signal ground |
| 7 | SIN | I | Synchronous inputs | Synchronous inputs |
| 8 | SOUT | O | Synchronous output | Synchronous output |

9.1.3 RS-485 & CAN Interface Definition



Figure10. M12-A Code 5Pin Male of Sensor

| M12-A 5pin | | | | | |
|------------|----------|-----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 |
| CA | Bro | Wh | Bl | Bla | Gr |
| N | wn (BN). | ite (WH). | ue (BU). | ck (BK). | ay (GY). |
| | SG | Vs | G | CA | CA |
| | ND | | ND | N H | N L |

| M12-A 5pin | | | | | |
|------------|----------|-----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 |
| R | Bro | Wh | Bl | Bla | Gr |
| S-485 | wn (BN). | ite (WH). | ue (BU). | ck (BK). | ay (GY). |
| | SG | Vs | G | 485 | 48 |
| | ND | | ND | A | 5 B |

9.1.4 RS-485 & CAN Pin Definition

Table17. RS-485 & CAN Pin Definition

| Number | RS-485 Name | Type | Description |
|--------|-------------|-------|--------------|
| 1 | SGND | Power | 485 ground |
| 2 | Vs | Power | Power+ |
| 3 | GND | Power | Power ground |
| 4 | 485 A | AIO | RS-485 A |
| 5 | 485 B | AIO | RS-485 B |

| Number | CAN Name | Type | Description |
|--------|----------|-------|--------------|
| 1 | SGND | Power | CAN ground |
| 2 | Vs | Power | Power+ |
| 3 | GND | Power | Power ground |
| 4 | CAN H | AIO | CAN high |
| 5 | CAN L | AIO | CAN low |

10 Cable information

Table18. Cable description

| Description | Digram | Note |
|--|--------|--------|
| M12-A Code 8Pin to DB9 External Power with Synchronous. Apply to: ● RS232 with synchronization function | | 1 |
| M12-A Code 8Pin to Open. Apply to: ● RS232 with synchronization function ● UART (TTL) with synchronization function | | 1 2 |
| M12-A Code 5Pin to Open. Apply to: ● RS485 ● CAN | | 1 2 |

Note1. All wire PUR, the default cable length is 3m, and the cable length can be ordered to be 0.5m, 1m, and 5m. The UART (TTL) interface does not recommend that all cables with a length of more than 3m can be customized with M12A header data cables for ease of use

Note2. Pin Definition Reference9.1

11 Wiring instructions

11.1 M12-A Code 8Pin to DB9 External Power with Synchronous

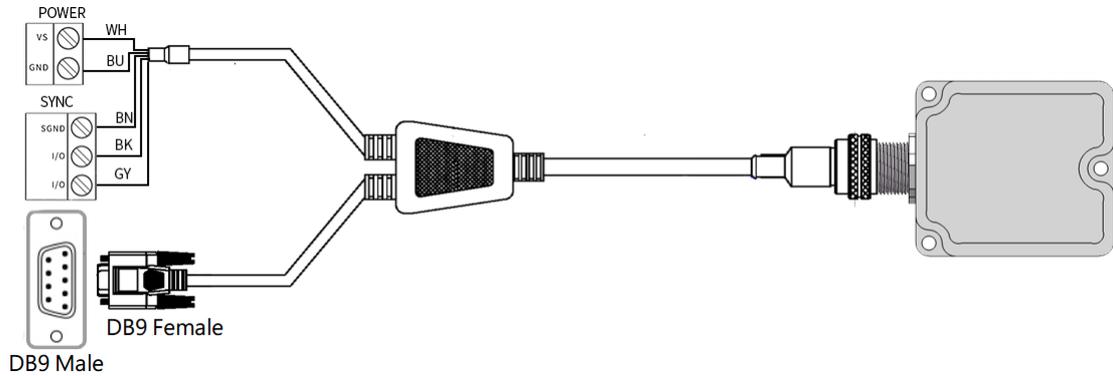


Figure11. M12-A Code 8Pin to DB9 External Power with Synchronous

11.2 M12-A Code 8Pin to Open

11.2.1 The synchronous input and output are co-located with the UART

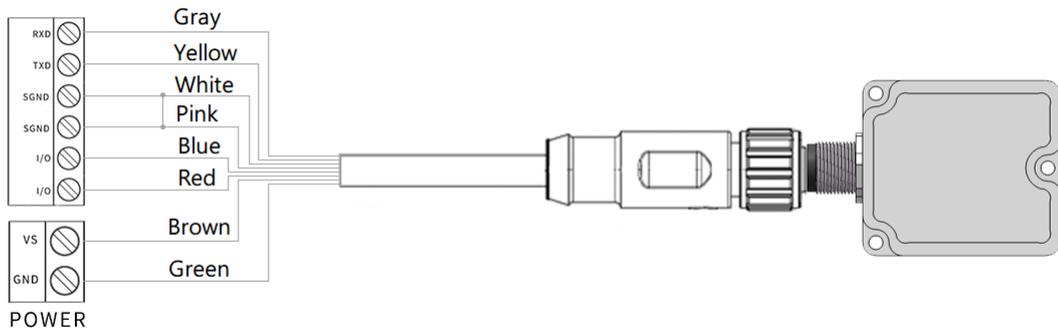


Figure12. M12-A Code 8Pin to Open Synchronous IO with UART Common Ground

- ✚ If the power supply system and the UART system reference ground are the same ground, then the SGND (white and pink wire) can be disconnected

11.2.2 The synchronous I/O is not in common ground with the UART

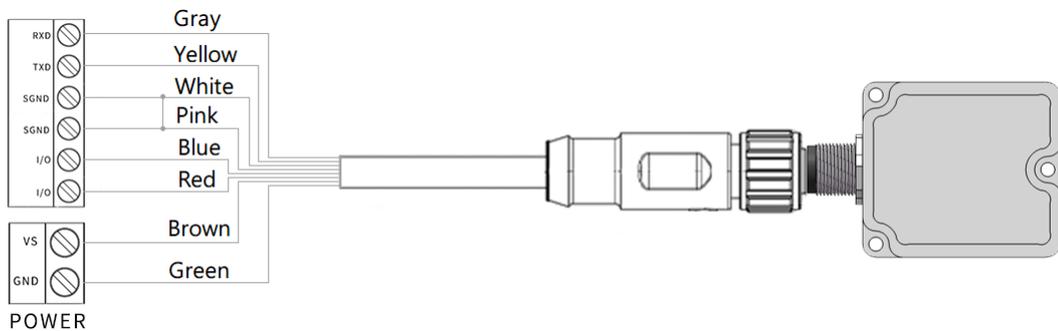


Figure13. M12-A Code 8Pin to Open Synchronous IO with UART Are Not In Common Ground

- ✚ If the power supply system and the UART system reference ground are the same ground, then the SGND (white wire) can be left unconnected
- ✚ If the power supply system and the synchronization system are referenced to the same ground, then the SGND (pink wire) can be disconnected

11.3 M12-A Code 5Pin to Open

11.3.1 RS-485

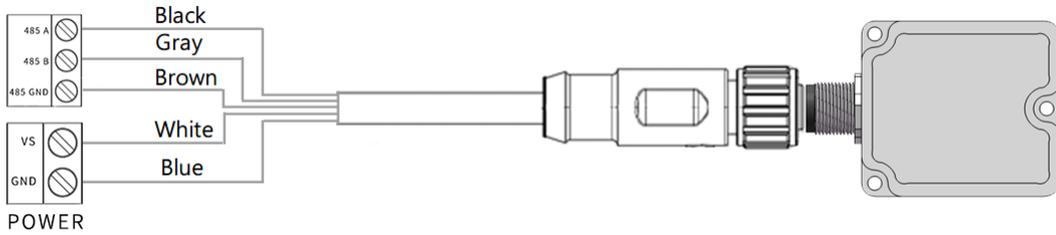


Figure14. M12-A Code 5Pin to Open RS-485

✚ If the 485 device does not have 485 GND, then the 485 GND (brown wire) can be disconnected

11.3.2 CAN

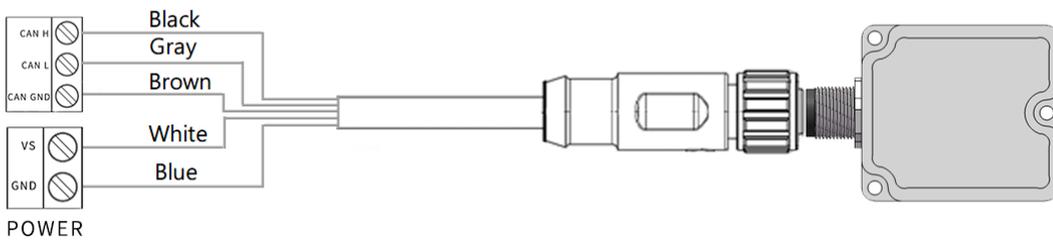


Figure15. M12-A Code 5Pin to Open CAN

✚ If the CAN device does not have CAN GND, then CAN GND (brown wire) can be disconnected

12 Software architecture

The HI14 series adopts the self-developed extended Kalman filter, IMU noise dynamic analysis technology and motion state self-adjustment technology, which can meet the accuracy of the attitude angle under high dynamic and reduce the drift of the heading angle. The algorithm architecture mainly includes four parts: IMU, fusion state, fusion algorithm, and data output.

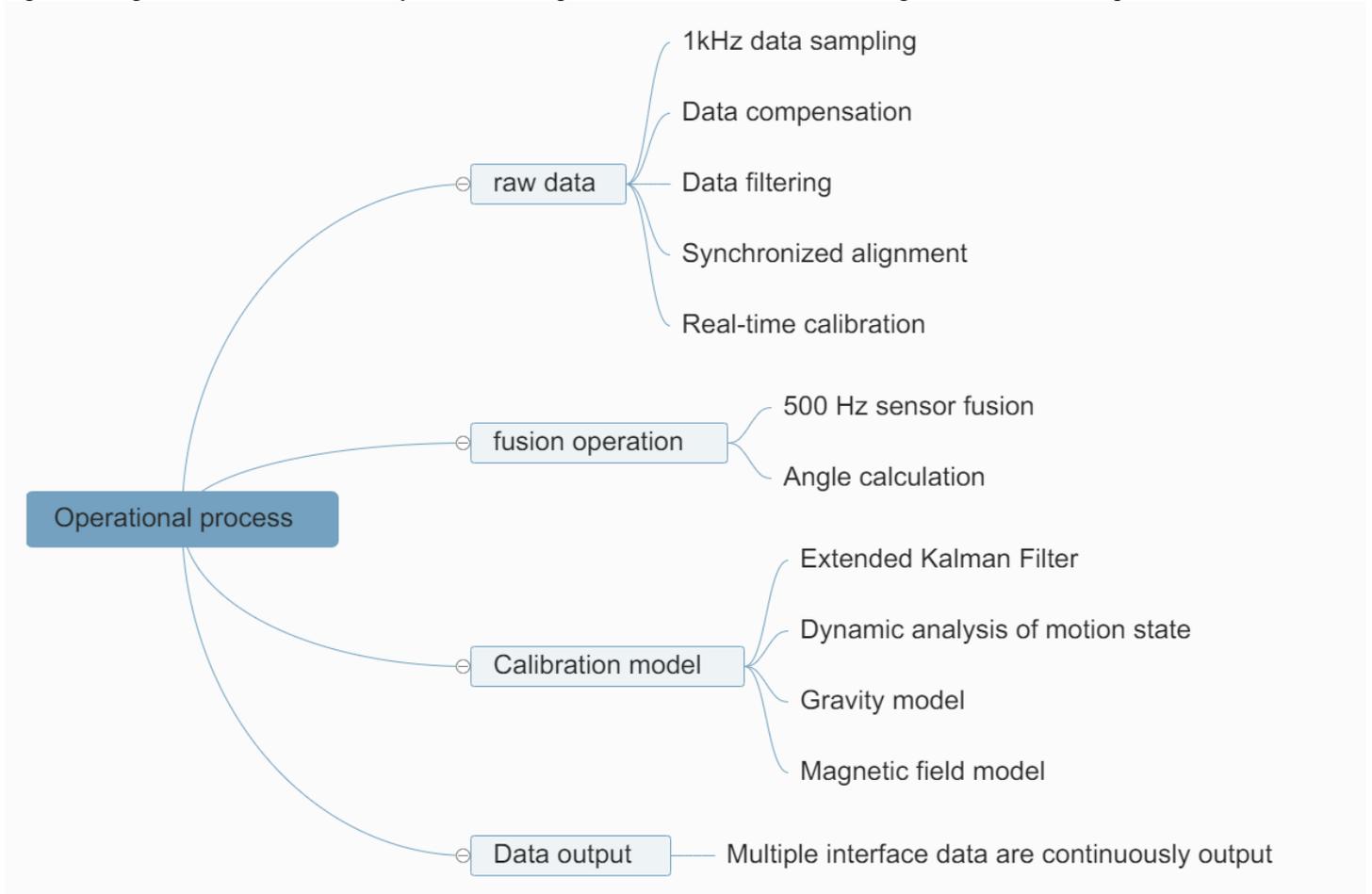


Figure16. Software Architecture

12.2 IMU subsystem

The main work of the IMU system is to calibrate and compensate the original data of the IMU, time alignment and other operations, so that the data of the IMU can better meet the needs of a variety of users

12.2.1 Raw data

The MCU collects raw data from the accelerometer, gyroscope, and geomagnetic field at the highest sampling frequency for post-processing

12.2.2 Low-pass filtering

The HI14 series provides users with a variety of low-pass digital filtering schemes, which can better filter out the noise interference of the actual use environment and meet the user's multi-scenario applications.

12.2.3 Factory calibration

In the manufacturing process, each MEMS IMU has some common bias, scale factor, cross-axis and other errors, in addition to being affected by temperature changes, so we minimize the impact of these errors through proprietary equipment in the process of production, manufacturing and testing.

12.2.4 Coordinate transformations

By default, we recommend that users install the product horizontally, but due to the user's usage scenario, sometimes the module has to be installed in other positions, so we can support the rotation of the sensor's coordinate system to better meet the user's installation needs. Coordinate transformation instructions can be found in the Instructions and Programming Manual

12.2.5 Online compensation

The user needs to maintain a static time of 1S when the power is on, and the product can automatically collect and calculate the current gyroscope bias state, which can better compensate the gyroscope data.

12.3 Data fusion

12.3.1 Extended Kalman Fusion

The processor uses the extended Kalman algorithm to solve the original data of accelerometer, gyroscope, and magnetometer at a fixed frequency (1000Hz by default) of quaternion full pose, and the fused information such as quaternion and Euler angle can be obtained through data fusion. At the same time, the bias of sensors such as gyroscopes and accelerometers can be estimated, which is important for systems that rely on low-latency, low-jitter attitude information as control input information.

12.3.2 Dynamic analysis of the state of motion

Based on the information provided by sensors such as accelerometers and gyroscopes, the motion state of the current carrier can be indirectly analyzed, so as to adjust the Kalman fusion state and keep the module performance in the best state.

13 Initial configuration

The HI14 series is designed with minimal configuration to achieve operations covering the vast majority of application scenarios. Therefore, the preset configuration can already meet many scenarios, but we also provide users with other configuration options to deal with special scenarios.

13.1 Initial configuration of the interface

Table19. Initial configuration of the interface

| Interface | Parameters | Value | Unit | Note |
|-----------|---------------------------|----------------------|------|------|
| UART | agreement | Binary Protocol(91). | | 1 |
| | Serial transfer rate | 115200 | bps | 2 |
| | Data frame rate | 100 | Hz | 3 |
| RS-485 | agreement | Modbus | | 1 |
| | Serial transfer rate | 115200 | bps | 2 |
| | Data frame rate | 50 | Hz | 3 |
| | Termination 120Ω resistor | nothing | | 4 |
| CAN | agreement | CANopen | | 1 |
| | Serial transfer rate | 500K | bps | 2 |
| | Data frame rate | 100 | Hz | 3 |
| | Termination 120Ω resistor | nothing | | 4 |

Note1.If you need to change the protocol, please refer to the instructions and programming manual

Note2.If you need to change the serial transmission rate, please refer to the instructions and programming manual

Note3.If you need to change the output frame rate, please refer to the instructions and programming manual

Note4.If you need to customize the 120Ω resistor, please contact us before purchasing

13.2 Initial configuration of the sensor

Table20. Initial configuration of the sensor

| Parameters | Value | Unit | Note |
|-------------------------|-------|-------|------|
| Gyroscope range | ±2000 | °/s | |
| 3dB bandwidth | 90 | Hz | |
| Accelerometer range | ±12 | g | |
| 3dB bandwidth | 80 | Hz | |
| Magnetic metering range | ±8 | Gauss | |
| mode | 6DOF | | 1 |

Note1.If you need to change the mode, please refer to the instructions and programming manual

13.3 Communication protocols

In order to support the diverse scenarios and communication needs of users, our modules support custom binary protocols, as well as common standard protocols such as Modbus and CANopen. Please refer to the Instructions and Programming Manual for the specific content of the protocol.

14 Synchronization function

If your system contains multiple subsystems such as radars, cameras, etc., then data synchronization between systems becomes extremely important. Our IMU supports synchronous pulse input, PPS input and synchronous output, which will be more convenient for users in the process of use.

Note: The IMU needs to be co-located with the external synchronization system

14.1 The IMU is triggered by an external system

14.1.1 Synchronous pulse input

Synchronous Pulse Input (SIN): The pin is in pull-up input mode and the idle state is high. When the module detects the falling edge, it outputs a frame of data. At this time, the module should be in synchronous trigger mode i.e. ONMARK mode.

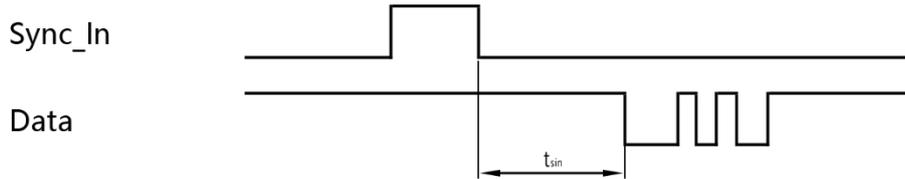


Figure17. Sync_In(SIN) Timing

Data Delay: The time interval between the falling edge and the data output is $0.78 \text{ ms} \pm 0.2 \text{ ms}$

14.1.2 Synchronize timestamps

The IMU can output PPS synchronization timestamps. The PPS synchronization timestamp refers to the time elapsed from the time the module detected the most recent falling edge signal to the time the current frame of data was sampled.

Note: How to configure triggers for ONMARK refers to the Programming Manual

14.2 The IMU triggers an external system

Data Synchronous Output (SOUT): The pin is the output mode, it is high (idle) when there is no data output, it becomes low when a frame of data is sent, and it returns high (idle) after a frame of data is sent. Example: By default, the module outputs 100Hz data, and the pin outputs a pulse with a 100Hz duty cycle of 50%.

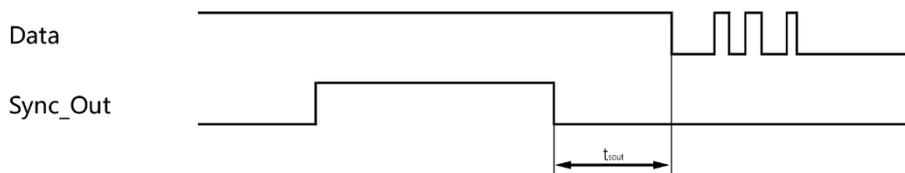


Figure18. Sync_Out(SOUT) Timing

Data Delay: The time interval between the output data of the module and the falling edge of the synchronous output is $10\mu\text{s} \pm 1\mu\text{s}$

15 Geomagnetic calibration

In most cases, the AHRS (9-axis) mode is susceptible to interference in the robot and indoor environment, resulting in heading errors. In a small number of open and non-magnetic field interference environments, you can try to use the geomagnetic auxiliary mode, such as the drone, before using the module needs to be configured to the geomagnetic auxiliary mode and geomagnetic calibration. For more information about the configuration commands, please refer to the Commands and Programming Manual CONFIG ATT MODE.

15.1 Geomagnetic calibration method

Calibration Prerequisites:

- Under the current test, the heading angle accuracy does not meet the requirements.
- There is a magnetic field interference in the module installation environment, which is fixed, and the distance between the interference magnetic field and the module will not change after installation (e.g. The module is installed on an iron material, because the iron will have magnetic field interference, then the iron needs to be rotated and calibrated together with the module, and the iron will not be separated from the module in use, once separated, it needs to be recalibrated. If the size of the iron is not fixed, or the distance from the module is not fixed, this interference cannot be calibrated, and can only be installed at a distance, and the safe distance is controlled at more than 40CM).

The module comes with an active geomagnetic calibration system, which does not require the user to send any instructions, the system automatically collects the magnetic field data for a period of time in the background, and analyzes and compares it, rejects abnormal data, and once the data is sufficient, it will try to calibrate the geomagnetic field. Therefore, when using the geomagnetic assist (9-axis) mode, the geomagnetic calibration can be done without any user intervention. However, the module still provides an interface for the user to check the current calibration status. The premise of automatic calibration is that the module needs to have sufficient attitude change and maintain it for a certain period of time, so that the internal calibration system can collect geomagnetic field information under different attitudes, so as to complete the calibration, and geomagnetic calibration cannot be carried out in the stationary state.

When using the module for the first time and using AHRS (9-axis) mode is required, the following calibration operation should be performed:

1. Check whether there is magnetic field interference in the surroundings: Desks, computers, motors, mobile phones, etc., which are ferrous or contain iron in the laboratory, are common dry areas. It is recommended to take the module to an open place outside, even if there is no condition to get it outdoors, and try to keep the module away from the interference source.

2. Slowly rotate the module in the smallest possible range (the position is as low as possible, just rotating), and let the module experience as many attitude positions as possible (each axis rotates at least 360° for about 1 minute) If the module is not successfully calibrated, it means that the surrounding geomagnetic field interference is relatively large.

3. If the customer's installation position is changed (for example, the last calibration was to hold the module to calibrate alone, but when it is used, it is installed on the target device). You will need to recalibrate with the target device.

4. USE LOG MAGCONFIG TO VIEW GEOMAGNETIC CALIBRATION PARAMETERS:

```
1. ...
2.
3. LIKES TO:
4. 0.029
5. -22.062
6. 11.926
```

If the MAG BIS is a 3 digit that is not all 0, it means that the geomagnetic calibration is successful, if the MAG BIS is all 0, it means that the geomagnetic calibration is not successful, please go back to 1 and start the calibration step again.

15.2 Common geomagnetic interference

Geomagnetic interference can be divided into space magnetic field interference and magnetic field interference in the sensor coordinate system, as shown in the figure below

| Distortions that move with the sensor | Distortions that do not move with the sensor |
|--|---|
|  |  |
| <ul style="list-style-type: none"> • Calibration errors • Hard iron effects • Soft iron effects • Etc. | <ul style="list-style-type: none"> • Spatial distortions • Temporal distortions • Etc. |

Figure19. Common Magnetic Field Interference

15.2.2 Space magnetic field interference

Definition: Magnetic field interference does not move with the motion of the sensor and is in the world coordinate system

Typical interference sources: all kinds of fixed geomagnetic interference sources, furniture, household appliances, cables, steel structures in the house, etc. All interference sources that do not move with the movement of the magnetic sensor, the following figure is a typical indoor magnetic field distribution map.

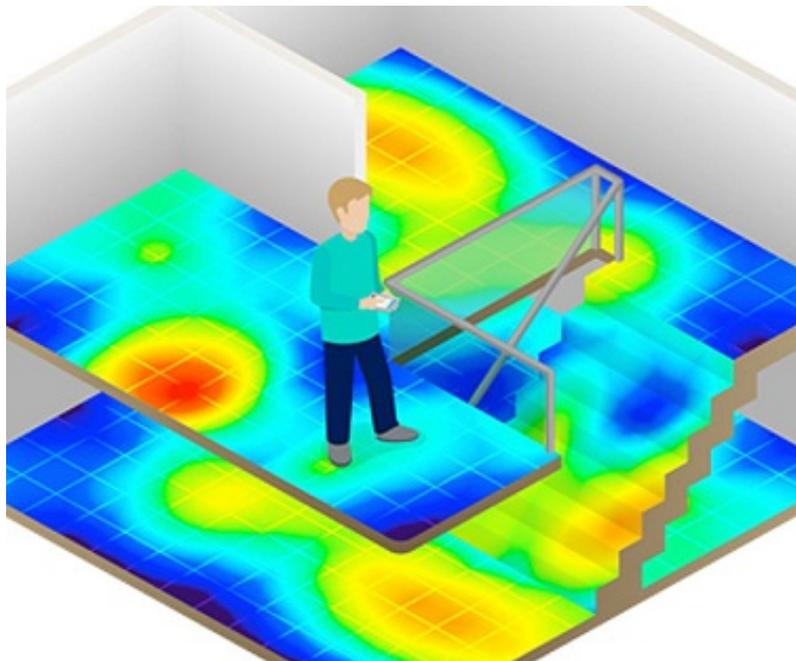


Figure20. Space Magnetic Field Interference

Impact on the module:

Regardless of whether the magnetic field sensor is well calibrated or not, the interference of these spatial magnetic fields (or the uneven environmental magnetic field) will cause the spatial geomagnetic field to distort. Geomagnetic compensation will be incorrect and the correct heading angle will not be obtained. They are the main reason why indoor geomagnetic fusion is difficult to use. This interference cannot be calibrated and can seriously affect the geomagnetic properties. Space magnetic field interference is especially severe indoors. Countermeasures: Only try to avoid such sources of interference

15.2.3 Interference in the sensor's coordinate system

Definition: A source of geomagnetic field interference moves with the motion of a sensor

Typical interference sources: PCBs fixed to modules, instruments and equipment, etc. They are treated as the same rigid body as the magnetic sensor and move with the motion of the magnetic sensor.

Impact on the module: Hard/soft magnetic interference to the sensor. These interferences can be well eliminated by geomagnetic calibration algorithms. Countermeasure: Perform geomagnetic calibration on the module.

15.3 Precautions for the use of geomagnetism

Spatial magnetic interference is particularly severe in indoor environments, and it cannot be eliminated by calibration. In the indoor environment, although the module has a built-in homogeneous magnetic field detection and shielding mechanism, the accuracy of the heading angle of the geomagnetically assisted (9-axis) mode largely depends on the degree of distortion of the indoor magnetic field, if the indoor magnetic field environment is very poor (such as next to the computer room, laboratory, workshop, underground garage, etc.), even after calibration, the heading angle accuracy may not be as good as that of the 6-axis mode, and even large angle errors may occur. The module's automatic geomagnetic calibration system can only handle fixed magnetic field disturbances that are mounted together with the module. If there is a magnetic field interference in the installation environment, this interference must be fixed, and the distance between the interfering magnetic field and the module will not change after installation (e.g., the module is installed in an iron material (robot)). Because the metal material of the robot will have magnetic field interference, it is necessary to rotate and calibrate the robot and the module together, and the module will not be separated from the robot (relative displacement occurs) in use, and once separated, it needs to be recalibrated.