1 FEATURES

1.1 Hardware

- High performance MEMS-IMU
- 5-36V Wide voltage input
- EtherCAT interface
- Factory calibrated temperature compensation from -40°C to +85°C, including scale factor, cross-axis, and bias calibration
- Gyroscope bias instability up to 1.6°/h
- Accelerometer bias instability up to 0.018mg
- Excellent vibration resistance
- Integrated temperature sensor
- Compact independent housing design for easy integration
- RoHS and CE certified

1.2 Software

- Adaptive Extended Kalman Fusion Algorithm with up to 1000Hz output rate and low latency
- Superior dynamic tracking performance with excellent vibration suppression
- Outstanding linear acceleration suppression
- Start-up time < 1s
- Comprehensive user configuration commands
- Multi-functional GUI for easy operation

2 APPLICATION

- Humanoid Robot

3 DESCRIPTIONS

3.1 Appearance

Figure1: HI15

3.2 Block Diagram

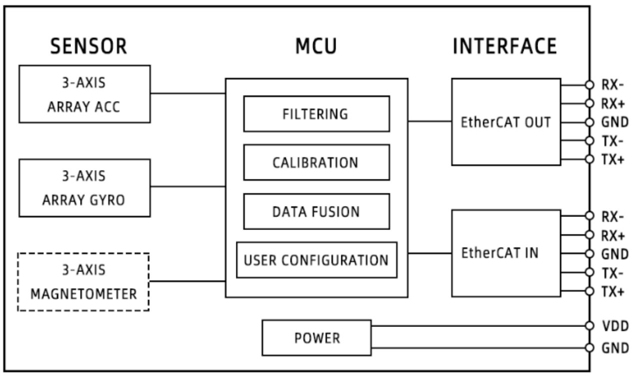

Figure2: Functional block diagram

Note1: The dashed line indicates that some models are not supported. Please refer to the product selection table (Table1) for details.

3.3 General Description

The HI15 series is an IMU/VRU sensor composed of high-performance MEMS-IMU, magnetometer, and enhanced single-axis gyroscope. It is equipped with proprietary adaptive extended Kalman filtering, IMU noise dynamic analysis algorithms, and carrier motion state analysis algorithms, ensuring high accuracy of attitude angles under high dynamics while reducing drift in heading angles.

The multifunctional GUI enables rapid evaluation: configuration, data visualization, firmware upgrades, and data logging..

For model selection and ordering information, please refer to Table 1 and Table 2.

Content

4 PRODUCT SELECTION

Table 1: Model Selection Information

HI15a-b-c-d[1]					
Company	Product	a- Sensor		b- Interface	c- OEM
HI	15	R2	6-DoF 1.6°/h 0.018mg	ECAT EtherCAT	000 Default
					XX OEM

Note1: Model Example:HI15R2-ECAT-000

Note2: All models feature full-temperature compensation

5 ORDERING

5.1 Ordering Information

Table 2: Ordering Information

Part Number	Name	Description	Note
HI15R2-ECAT-000	IMU/VRU Module	6-DoF 1.6°/h 0.018mg	

5.2 Contact Us

1. Email: overseas1@Hipnuc.com
2. Website: www.hipnuc.com

6 DOCUMENT INFORMATION

6.1 Scope

This documentation applies to hardware version A0 and above. Version change history is as follows:

Table 3: Hardware Version Changes

Product	Version	Changes
HI15	A0	Initial version
	A2	The casing size has been changed, and an indicator light has been added.

6.2 Document Information

Table 4: Document Version

Version	Date	Sections	Changes
1.0	Feb 17, 2025	-	Initial version
1.1	April 9, 2025	1,7.12	Change product images and product dimensions.
1.2	Jun 6, 2025	7.3 7.4 7.12	Modify product dimension parameters and sensor-related parameters
1.3	2025-9-22		Remove the HI15M0 model.

6.3 Related Documents and Development kits

1. *Command and Programming Manual*
2. *CAE/Step*
3. *CE/RoHS Certification documents*
4. *GUI Software*

7 SPECIFICATIONS

Unless otherwise specified, test conditions: Temperature 25℃, Supply Voltage 24V.

7.1 Absolute Maximum Ratings

Table 5: Absolute Maximum Ratings

Parameters	Limit	Comment
Mechanical Shock	2000g	Duration < 1 ms
Storage Temperature	-40℃-85℃	
ESD HBM	15KV	JEDEC/ESDA JS-001
Input Voltage (absolute max)	40V	
IO To GND	-0.3-5V	

7.2 Normal Operating Conditions

Table 6: Normal Operating Conditions

Parameters	Condition	Min	Typical	Max	Unit	Note
Input Voltage		5	-	40	V	
Power Consumption		1	1.2	1.3	W	
Operating Temperature		-40	-	85	℃	
Gyroscope Range		125	2000	2000	°/s	1
Accelerometer Range		3	12	24	g	
Startup Time				2	s	2

Note1: Start-up time refers to the duration from power-on to valid data output. The module should remain stationary during this period

7.3 Gyroscope

Table 7: Gyroscope

Parameters	Condition	Min	Typical	Max	Unit	Note
Range			±2000		°/s	
Resolution			16bit			
Scale Factor	100°/s		<280	300	ppm	1
Non-linearity		-0.05	-	0.05	%Fs	2
3dB Bandwidth			80	200	Hz	
Sampling Rate			1000		Hz	
Bias Instability	Allan Variance		1.6		°/h	3
Bias Stability	10 s averaged		5		°/h	
Bias Repeatability			8		°/h	
Angular Random Walk (ARW)	Allan Variance		0.25		°/√h	3
Bias Temperature Variation	(-40-85℃)		<0.09	0.2	°/s	4
Gyro g-Sensitivity	All axes		0.1		°/s/g	

Note1: The rate table rotates 10 turns in both directions, and the average is measured

Note2: The maximum deviation from the best-fit line within the specified range

Note3: Refer to the 7.7 Allan variance curve.

Note4: Measured using the rate table in the Hipnuc laboratory temperature chamber, with a temperature rise rate of less than 3℃/min. Detailed data can be found in Figure 7 temperature compensation curve.

7.4 Accelerometer

Table 8: Accelerometer

Parameters	Condition	Product	Min	Typical	Max	Unit	Note
Range				±12	24	g	
Resolution				16bit			
Initial Bias					5	mg	1
Non-linearity				0.5		%Fs	
3dB Bandwidth				90	200	Hz	
Sampling Rate				1600		Hz	
Bias Instability	Allan Variance			0.018		mg	2
Bias Stability	10 s averaged			0.035		mg	
Bias Repeatability				0.15		mg	
Velocity Random Walk (VRW)	Allan Variance			0.04		m/s/√h	2
Bias Temperature Variation	-40-85℃			<2.5	5	mg	3

Note1: The value may change after user installation; the actual value shall prevail. Refer to 7.6 Initial Bias

Note2: Refer to the 7.7 Allan variance curve.

Note3: Note4: Measured using the rate table in the Hipnuc laboratory temperature chamber, with a temperature rise rate of less than 3℃/min. Detailed data can be found in Figure 7 temperature compensation curve

7.5 Temperature

Table 9: Temperature

Parameters	Condition	Min	Typical	Max	Unit	Note
Range		-104	-	150	℃	
Offset error			±1		K	

7.6 Initial Bias

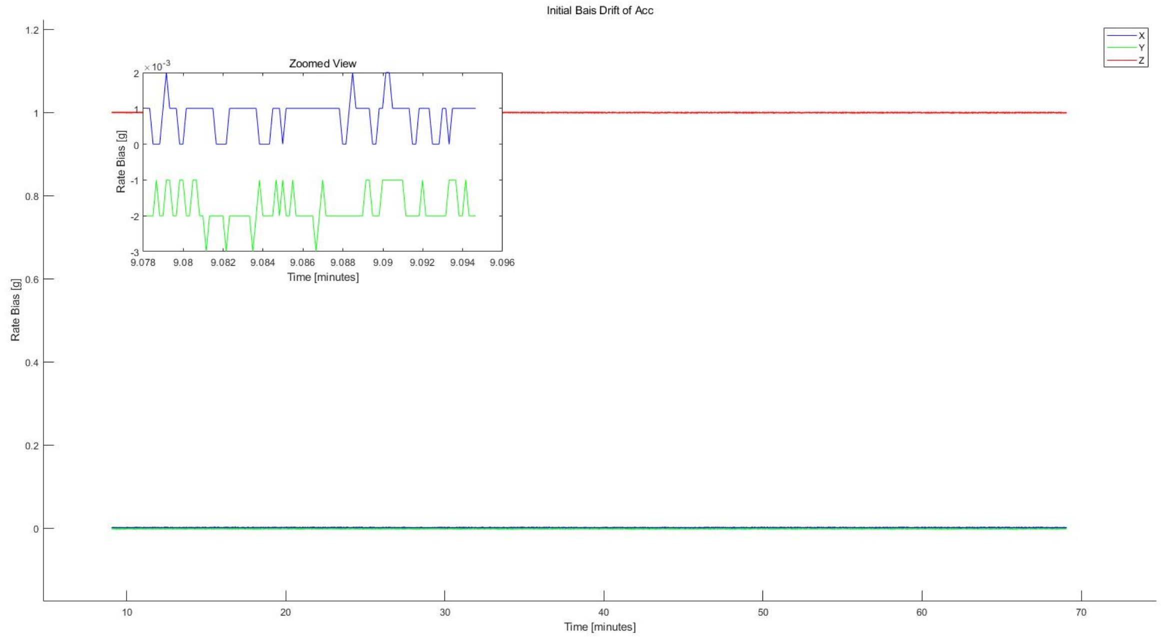

Figure3: HI15R2 initial bias drift of accelerometer

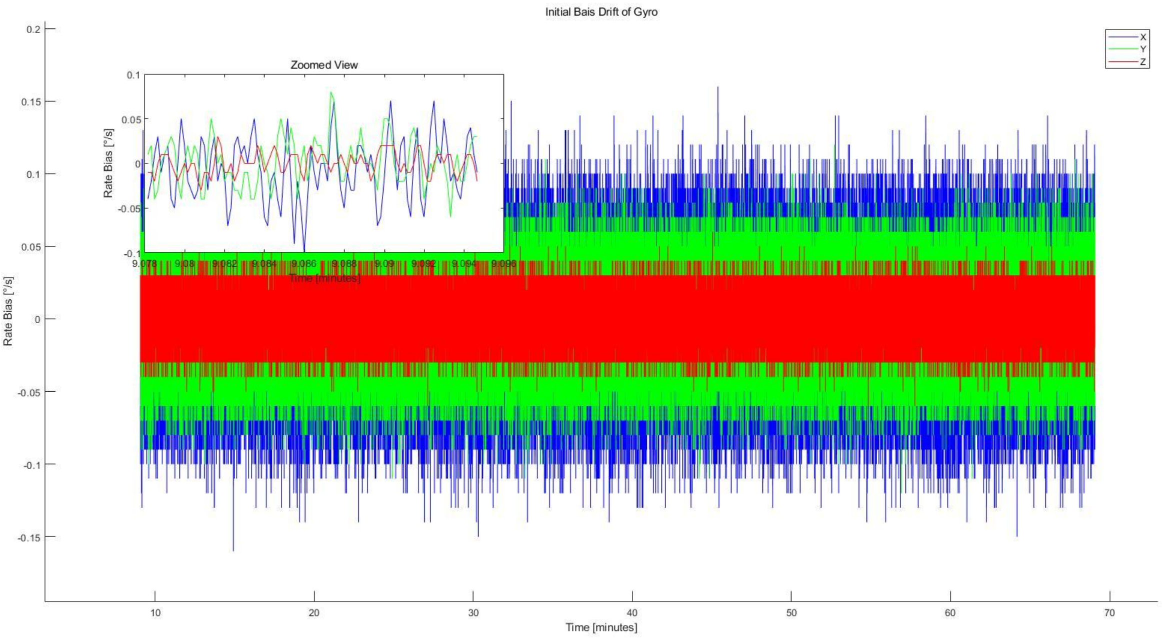

Figure4: HI15R2 initial bias drift of gyroscope

7.7 Allan Variance

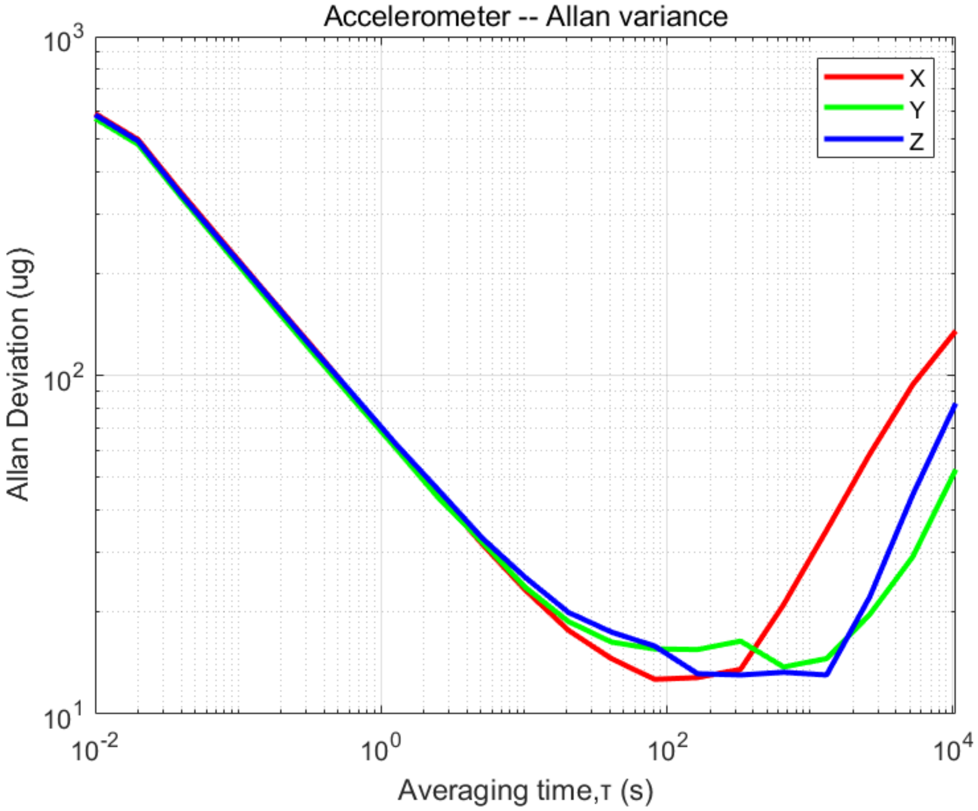

Figure5: HI15R2 accelerometer allan variance

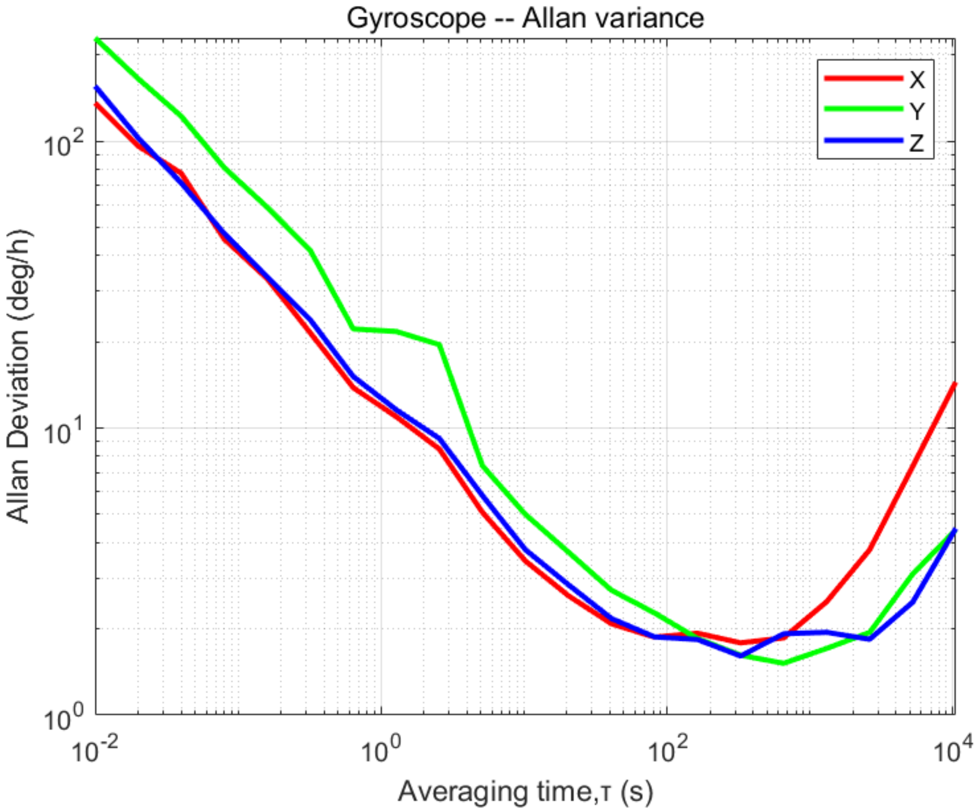

Figure6: HI15R2 gyroscope allan variance

7.8 Temperature Characteristics of Gyroscope and Accelerometer Bias

The tested sample was heated from -40℃ to 85℃, and the bias data of the sample was compensated. The compensation results are as follows

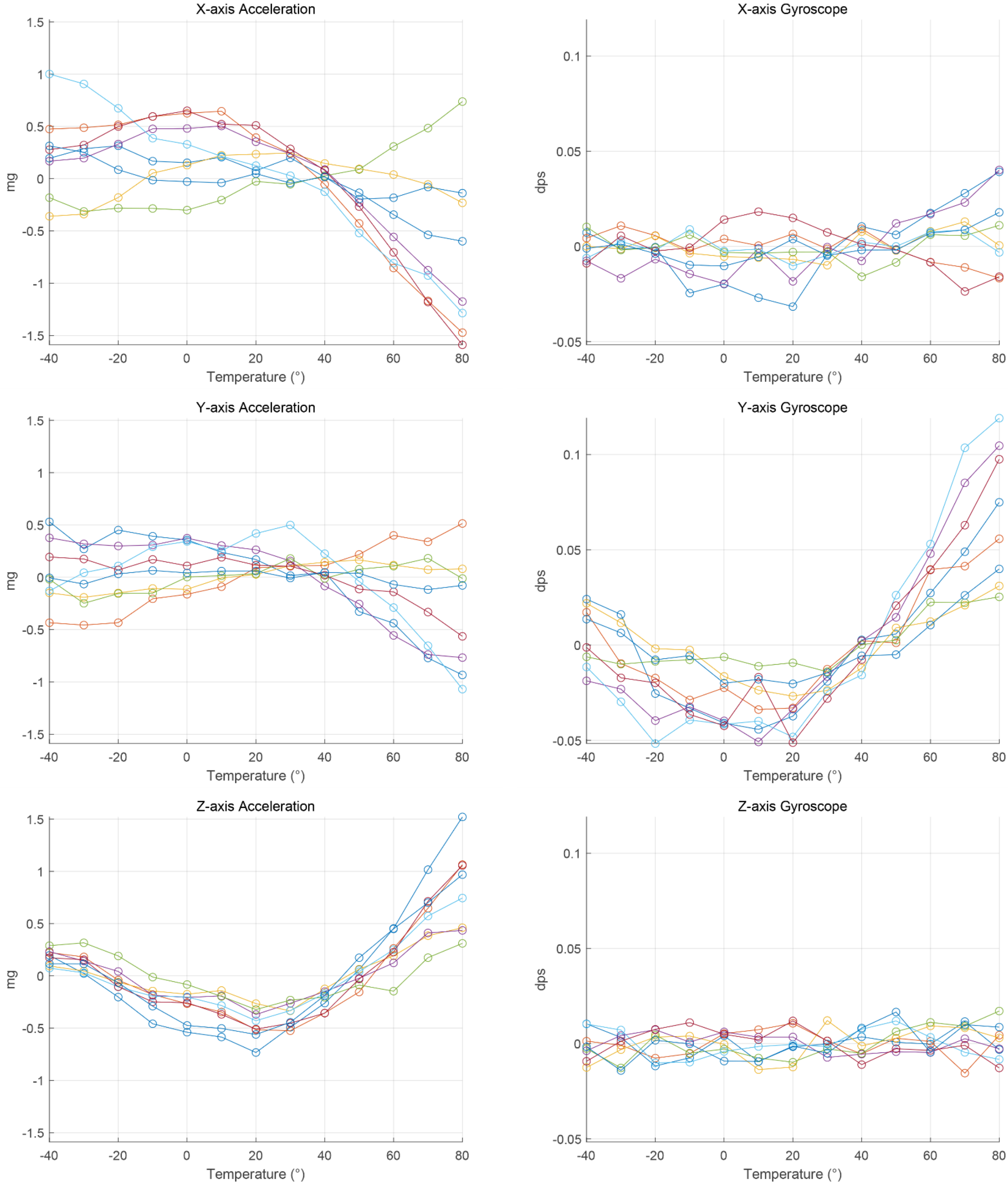

Figure7: Accelerometer and Gyroscope Temperature Compensated Curve

7.9 Fusion Parameters

Table 10: Fusion Parameters

Parameters	Value
Pitch	±90°
Roll	±180°
Yaw	±180°
Quaternion	Supported
Angle Resolution	0.01°

7.10 Attitude Accuracy

Table 11: Attitude Accuracy

Parameters	Condition	Product	Min	Typical	Max	Unit	Note
Pitch/Roll (Static)				0.15	0.2	°	
Pitch/Roll (Dynamic)				0.15	0.2	°	
Yaw Static Drift (6-DoF)	2h static			0.15	0.2	°	1
Yaw Accumulated Rotation Error	100°/s rotation 3600°			<2	3	°	2

Note1: Module horizontal static for 2h

Note2: Accumulated yaw error after 10 continuous rotations on rate table

7.11 Mechanical and Environmental

Table 12: Mechanical and Environment

Parameters	Product	Value	Note
Dimensions		39.1X36X13mm	
Weight		25g	
Housing Material & Process		Aluminum Alloy CNC	
Assembly Screws		M2.5	
Connector Type	Power	SM02B-PASS-1	
	Signal	SM05B-GHS-TB	
Vibration Resistance		1.0mm(10Hz-58Hz)&≤20g(58Hz-600Hz)	
Environmental Protection		RoHS 2011/65/EU	
EMC		LVD Directive 2014/35/EU	
Drop Test		Free fall from a height of 75 cm, 3 times.	
Temperature Shock		Temperature shock: −40 °C to +85 °C transition within 1 h, 5 cycles.	

7.12 Dimensions and Pin Definition

All dimensions in millimeters (mm).

7.12.1 HI15 Dimensions

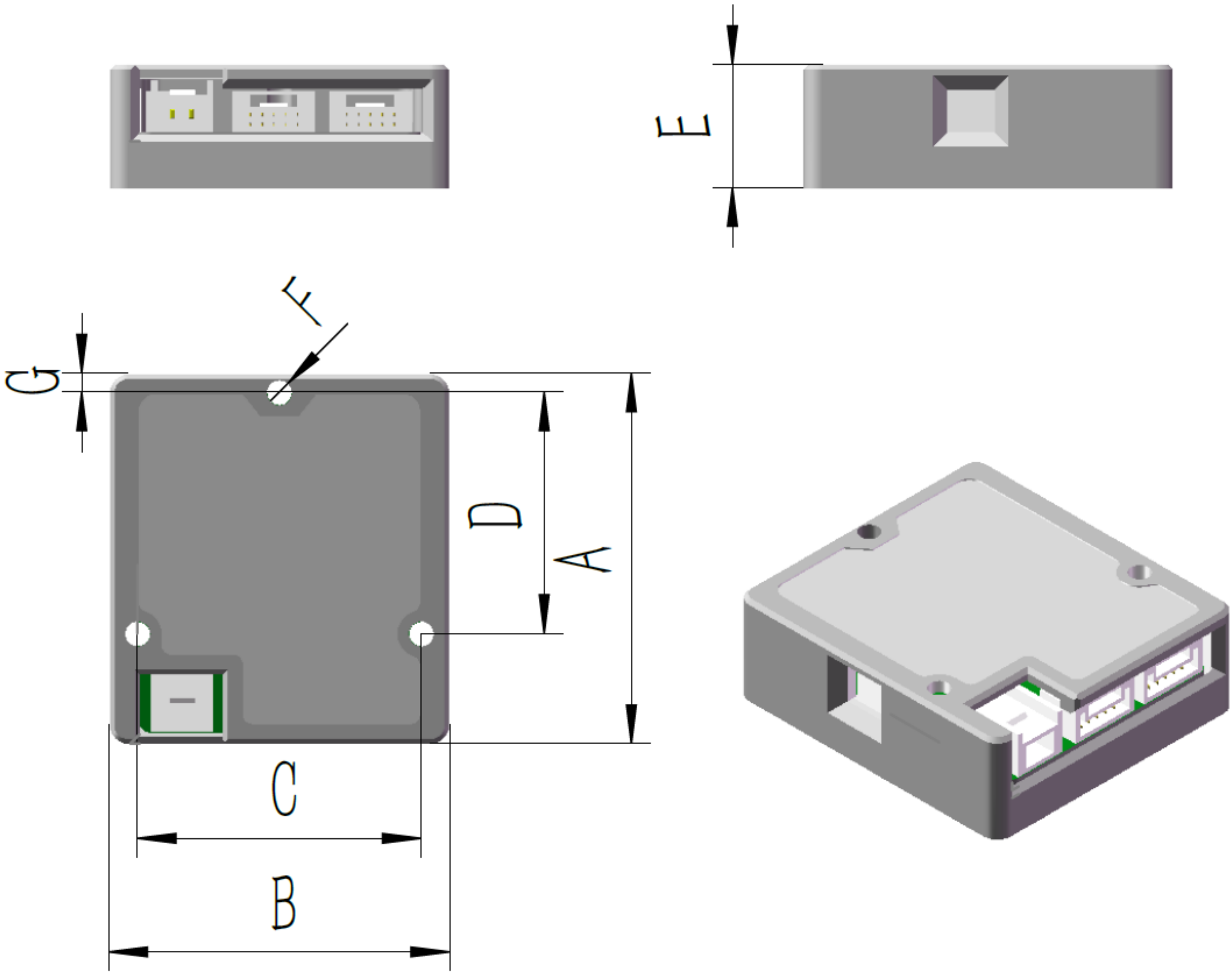

Figure8: HI15 interface mechanical dimension

7.12.2 HI15 Dimensions Table

Table 13: HI15 dimensions table

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	38.9	39.1	39.3
B	35.8	36	36.2
C	29.8	30	30.2
D	25.3	25.5	25.7
E	12.8	13	13.2
F	ϕ2.45	ϕ2.6	ϕ2.75
G	1.8	2	2.2

7.12.3 HI15 Pin Definitions

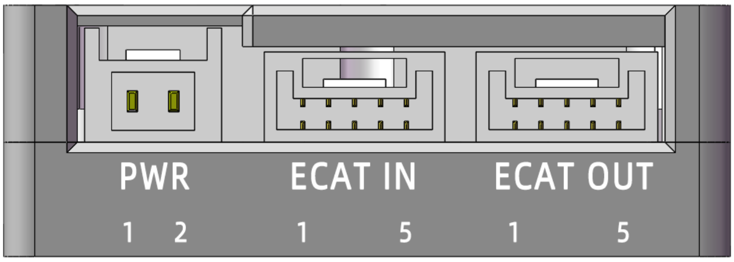

Figure9: Pin configuration as seen from front of HI15

Table 14: PWR Pin Definitions

Pin Number	Pin Name	Type	Function	Note
1	VCC	Power	Supply Voltage: 5 to 36 V	
2	GND	Power	GND	

Table 15: EtherCAT Pin Definitions

Pin Number	Pin Name	Type	Function	Note
1	TX+	AIO		
2	TX-	AIO		
3	GND	Power	GND	
4	RX+	AIO		
5	RX-	AIO		

Table 16: Matching Connectors

The following is a connector from JST, which can be used to connect HI15 series sensors to the power supply and EtherCAT network.

Connector	JST Number	Type	Qty	Note
1	PARP-02V	Power connector	1	
2	GHR-05V-S	EtherCAT connector	2	

8 COORDINATE SYSTEM

8.1 Coordinate System

The carrier frame uses Right-Front-Up (RFU) coordinate system, while the geographic frame uses East-North-Up (ENU) coordinate system. The acceleration and gyroscope axes are shown in the following figure:

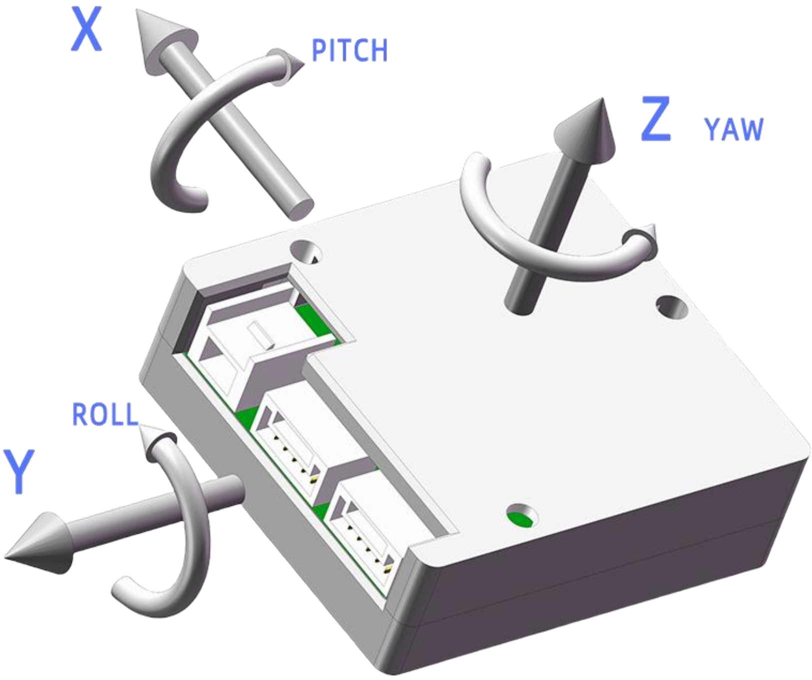

Figure10: HI15 Coordinate System

The Euler angle rotation sequence is East-North-Up-312 (first rotate around Z-axis, then X-axis, and finally Y-axis). The specific definitions are as follows:

Rotation around Z-axis: Yaw\psi(ψ) -180° - 180°

Rotation around X-axis: Pitch\theta(θ) -90°-90°

Rotation around Y-axis: Roll\phi(ϕ) -180°-180°

If the module is considered analogous to an aircraft body frame,, the positive Y-axis should be considered as the heading direction. When the sensor frame aligns with the inertial frame, the ideal Euler angle output is: Pitch = 0°, roll = 0°, yaw = 0°.

If users need to change the default coordinate system of the sensor, they can refer to the instruction and programming manual.

8.2 Center of Sensor

Table 17: HI15 Center of Sensor

Axis	X-offset	Y-offset	Z-offset	Unit
X	0	-1.5	2.8	mm
Y	0	-1.5	2.8	mm
Z	0	-1.5	2.8	mm

8.3 Installation

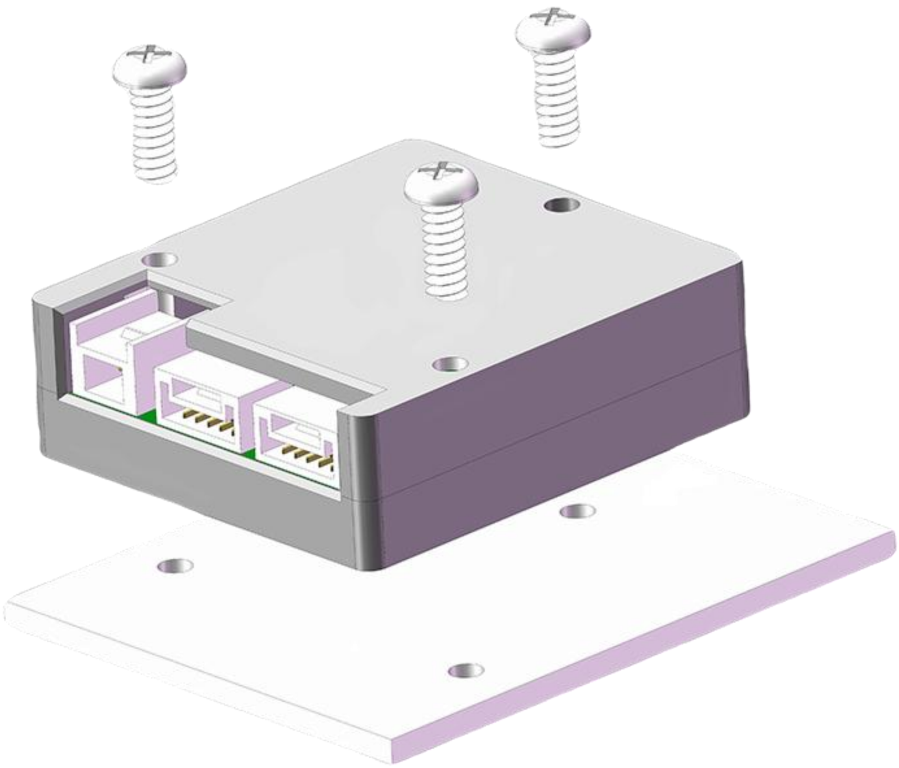

Figure11: Installation diagram

Note1: If other installation methods are required, please refer to the instruction and programming manual to rotate the coordinate system.
Note2: It is recommended to install the module in a location on the tested object where vibration and temperature variations are minimal, and ensure a rigid connection with the tested carrier.

9 INITIAL CONFIGURATION

The HI15 series is designed with the intention of requiring minimal configuration from users to achieve operations that cover most application scenarios. Therefore, the default configuration is sufficient for many working conditions, but we also provide additional configuration options to address special scenarios. Initial sensor configuration.

Table 18: Sensor Initial Configuration

Parameters	Value	Unit	Note
Gyroscope Range	±2000	°/s	
3dB Bandwidth	80	Hz	
Accelerometer Range	±12	g	
3dB Bandwidth	90	Hz	
Model	6-DoF		

10 PROTOCOL

EtherCAT TxPDO Channel Output of IMU Data

10.1 Overview of Object Dictionary Structure and Relationships

0x6000:IMU data object. Defines the actual data being transmitted, including acceleration, angular velocity, quaternion, and status information.

0x1A00:TxPDO mapping object. Maps the sub-items of 0x6000.

0x1C13:SyncManager 3 assignment object. Points to 0x1A00.

The master reads the mapping entries configured in 0x1A00 via SyncManager3, thereby receiving the real-time IMU data contained in 0x6000.

10.2 0x6000 Structure of Data Objects

Object 0x6000 defines the IMU data output via TxPDO, including acceleration, angular velocity, attitude quaternion, and IMU status information.

Table 19: Structure of Data Object 0x6000

Sub-index	Name	Data Type	Description
0x01	acc_x	REAL32	Acceleration along X-axis, unit: m/s^2
0x02	acc_y	REAL32	Acceleration along Y-axis, unit: m/s^2
0x03	acc_z	REAL32	Acceleration along Z-axis, unit: m/s^2
0x04	gyr_x	REAL32	Angular velocity about X-axis, unit: rad/s
0x05	gyr_y	REAL32	Angular velocity about Y-axis, unit: rad/s
0x06	gyr_z	REAL32	Angular velocity about Z-axis, unit: rad/s
0x07	q0	REAL32	Quaternion W
0x08	q1	REAL32	Quaternion X
0x09	q2	REAL32	Quaternion Y
0x0A	q3	REAL32	Quaternion Z
0x0B	imu_state	UINT16	IMU state: Number of IMU modules operating normally

10.3 IMU_STATE Bit Definition

The imu_state uses the lower 4 bits (bit0 ~ bit3) to represent the status of IMU0 ~ IMU3 respectively. Each bit being 1 indicates the corresponding IMU is functioning properly, while 0 indicates a fault or disconnection.

Examples:

bit0=1 IMU0 is functioning properly.

bit1=1 IMU1 is functioning properly.

bit2=1 IMU2 is functioning properly.

bit3=1 IMU3 is functioning properly.

Thus:

imu_state=0xF(i.e.,1111)All 4 IMUs are functioning properly.

imu_state=0xE(i.e.,1110)IMU0 is faulty.

imu_state=0x3(i.e.,0011)IMU2 and IMU3 are faulty.

