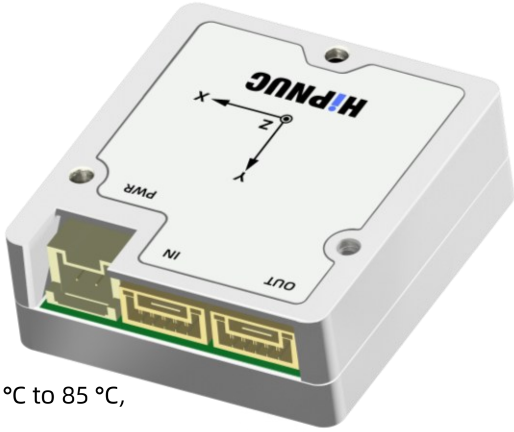
HiPNUC

HI15 Series Datasheet

EtherCAT IMU/VRU Module

1 Features

1.1 Hardware



- High-performance, low-noise MEMS IMU
- Wide input voltage range: 6 ~ 36 V
- EtherCAT interface for real-time communication
- Designed for strong vibration resistance, suitable for vibration-intensive applications
- Integrated temperature sensor
- Compact size: 39.15 × 36 × 13 mm, easy to integrate
- Factory-compensated and calibrated over the full temperature range of -40 °C to 85 °C, including bias, scale factor, and cross-axis calibration
- Compliant with RoHS requirements; EMC and CE compliance documents are available upon request
- Customization options are available upon request.

1.2 Software

- Adaptive EKF fusion algorithm
- Output data rate up to 1000 Hz
- Optimized attitude tracking and vibration suppression for dynamic motion scenarios
- Reduced impact of linear acceleration on attitude estimation under typical operating conditions
- Supports firmware upgrade via FoE

2 Applications

The HI15 series is designed for high-performance attitude sensing and complex operating conditions. It is suitable for attitude measurement and control applications under temperature variation, vibration, and dynamic motion conditions. Typical applications include:

- Humanoid robots
- Angle monitoring for industrial equipment

3 Description

3.1 System Block Diagram

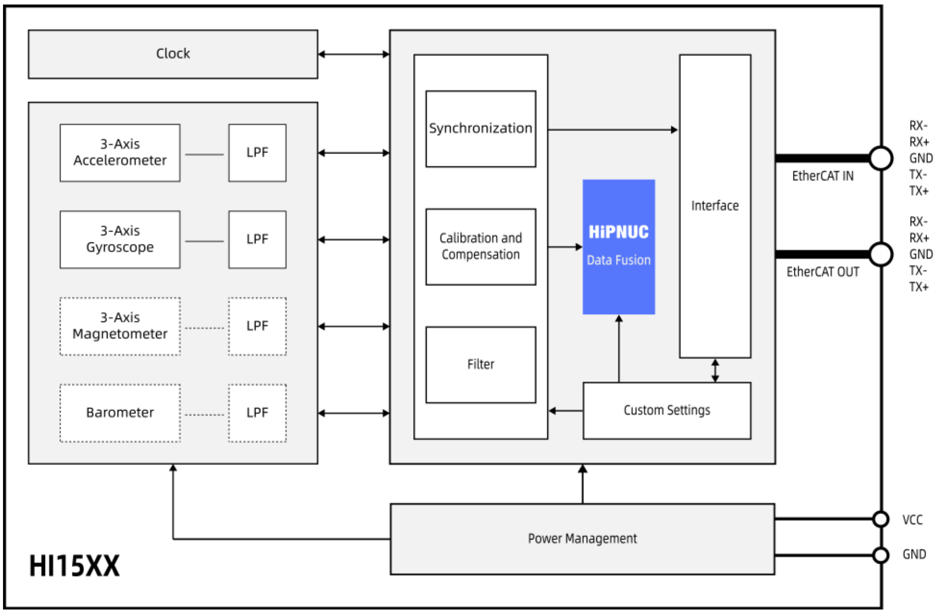


Figure 1: HI15 System Block Diagram

Note 1: Dashed lines indicate functions not supported by some models. See Table 1 for details.

3.2 General Description

The HI15 series is an IMU/VRU sensor module based on a MEMS IMU. It integrates self-developed adaptive extended Kalman filtering, IMU noise dynamic analysis, and platform motion state analysis algorithms, and provides users with raw inertial data (acceleration and angular rate) as well as computed attitude data (Euler angles, quaternions, etc.).

Before shipment, each module is calibrated and compensated for temperature, bias, scale factor, and cross-axis errors. Data is transmitted via the EtherCAT interface.

Contents

4 Product Selection

Table 1: Selection Information

HI15a-b-c							
Identifier	Series	a - Sensor Configuration		b - Data Interface		c - Other Information	
HI	15	R2	IMU/VRU	ECAT	EtherCAT	000	Z-axis up (default)
						010	Z-axis down

Note 1: Standard models are listed in the Ordering Information section. Other models can be customized.

5 Ordering Information

5.1 Ordering Code

Table 2: Ordering Code

Part Number	Name	Description	Note
HI15R2-ECAT-000	IMU/VRU Module	IMU/VRU module, Z-axis up	
HI15R2-ECAT-010	IMU/VRU Module	IMU/VRU module, Z-axis down	

5.2 Contact Information

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

6 Document Information

6.1 Hardware Revision History

Table 3: Hardware Revision History

Revision	Description
A1	Initial release
A2	Enclosure size updated; indicator LED added
A5	Eye diagram optimized, EMC improved, signal connector upgraded to 10155242-05111LF

6.2 Revision History

Table 4: Revision History

Revision	Date	Author	Changes
1.0	Feb. 17, 2025	Hipnuc	Initial release
1.1	Apr. 9, 2025	Hipnuc	Updated product image and dimensions
1.2	Jun. 6, 2025	Hipnuc	Updated dimensional parameters and sensor-related parameters
1.3	Sep. 22, 2025	Hipnuc	Removed HI15M0 model
1.4	Nov. 16, 2025	Hipnuc	Signal connector upgraded to 10155242-05111LF; coordinate system description added
1.5	Jan. 6, 2026	Hipnuc	Dimensions updated; parameters refined
1.6	Mar. 14, 2026	Hipnuc	Added FoE firmware upgrade description

6.3 Related Documents

1. Command and Programming Manual
2. EtherCAT ESI file
3. STEP file
4. RoHS, EMC, CE, and other compliance documents
5. GUI software

7 HI15 System Architecture

The HI15 series is a family of sensor modules supporting IMU and VRU configurations. The product can output acceleration, angular rate, Euler angles, quaternions, and other data.

Depending on the model configuration, the HI15 integrates a 3-axis accelerometer, a 3-axis gyroscope, and a high-performance processor. The controller is mainly used for sensor synchronization, calibration, algorithm fusion, and user configuration. Based on application scenarios and sensor characteristics, the module supports modes such as 6-DoF and humanoid robot mode. Refer to the Command and Programming Manual for details.

7.1 IMU

The HI15 can be used as an inertial measurement unit (IMU), providing accurate 3-axis acceleration and 3-axis angular rate data. This data is collected by the built-in high-precision accelerometer and gyroscope, and can reflect the motion state and dynamic changes of an object in three-dimensional space in real time.

Compared with uncompensated and uncalibrated raw inertial devices, the HI15 has undergone system-level calibration and compensation before shipment, which helps improve output consistency, accuracy, and stability. These calibrations include cross-axis, scale factor, bias, and temperature compensation.

7.2 VRU

Using the fusion algorithm, the HI15 can output attitude information referenced to gravity, mainly including pitch and roll. In 6-DoF mode, it can also output an estimated yaw value, but this value accumulates drift over time.

8 Interface and Pin Definition

8.1 Pin Definition

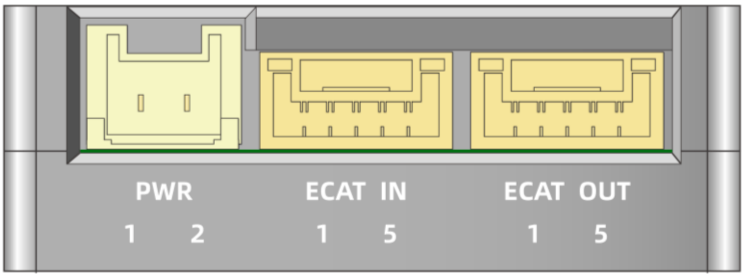


Figure 2: HI15 Pin Numbering

Table 5: PWR Pin Definition

Pin No.	Name	Type	Description	Remark
1	VCC	Power	Power input 6 ~ 36 V	
2	GND	Power	GND	

Table 6: ECAT IN and ECAT OUT Pin Definition

Pin No.	Name	Type	Description	Remark
1	TX +	Differential	Differential transmit positive	
2	TX-	Differential	Differential transmit negative	
3	GND	Power	Ground	
4	RX +	Differential	Differential receive positive	
5	RX -	Differential	Differential receive negative	

Table 7: Connectors

No.	HI15 Connector Part Number	Mating Connector Part Number	Description	Quantity
1	SM02B-PASS-1	PARP-02V SPHD-001T-P0.5	Power connector	1
2	10155242-05111LF	10155244-05111LF 10155245-21LF	Signal connector	2

8.2 Cable Assembly

The HI15 is supplied with signal cables and a power cable as standard.

Table 8: Cable List

No.	Name	Description	Quantity
1	10155244-05111LF-0.5V-RJ45	EtherCAT signal cable, 50 cm	2
2	10155244-05111LF-0.2V-Open	EtherCAT signal cable, 20 cm	2
3	PARP-02V-0.2V-Open	HI15 power cable, 20 cm	1

Note 1: Standard accessories include two 10155244-05111LF-0.5V-RJ45 cables. If one set is required for each HI15 unit, please contact our sales team.

9 Sensor Performance Specifications

9.1 Gyroscope

Table 9: Gyroscope Specifications

Parameter	Condition	Min	Typ	Max	Unit	Remark
Full Scale Range			±250 ±500 ±1000 ±2000		°/s	Default: ±2000
Resolution			16		bit	
Scale Factor Error	100 °/s rotation		<600	850	ppm	Typ: RMS
Nonlinearity			±0.05		%FS	1
Noise Density	Bandwidth 47 Hz		0.008		°/s/√Hz	
3 dB Bandwidth			80	200	Hz	2
Initial Bias			0.1	±0.45	°/s	3
Sample Rate			1000		Hz	
Bias Instability Allan Variance	X Y Z		1.5 1.9 1.7	2.5 3.2 3.2	°/h	Typ: 1σ Max: 3σ
Bias Stability 10 s averaging	X Y Z		5.5 7.5 5.5	7 9 7	°/h	Typ: 1σ Max: 3σ
Bias Repeatability	X Y Z		11.5 15 9.5	21 30 15	°/h	
Angle Random Walk (ARW) Allan variance	X Y Z		0.3 0.4 0.2	0.6 0.7 0.4	°/√h	Typ: 1σ Max: 3σ
Bias Change Over Temperature	-40 °C to 85 °C		0.09	0.2	°/s	4
g-Sensitivity	XYZ		0.05		°/s/g	

Note 1: Maximum deviation from the best-fit straight line within the specified range.

Note 2: Different modes have different bandwidths; the default 6-DoF mode bandwidth is 80 Hz.

Note 3: After initial bias calibration, the bias can be estimated in real time by the algorithm engine.

Note 4: Measured using a thermal chamber and rate table in the Hipnuc laboratory, with a temperature ramp rate of less than 3 °C/min.

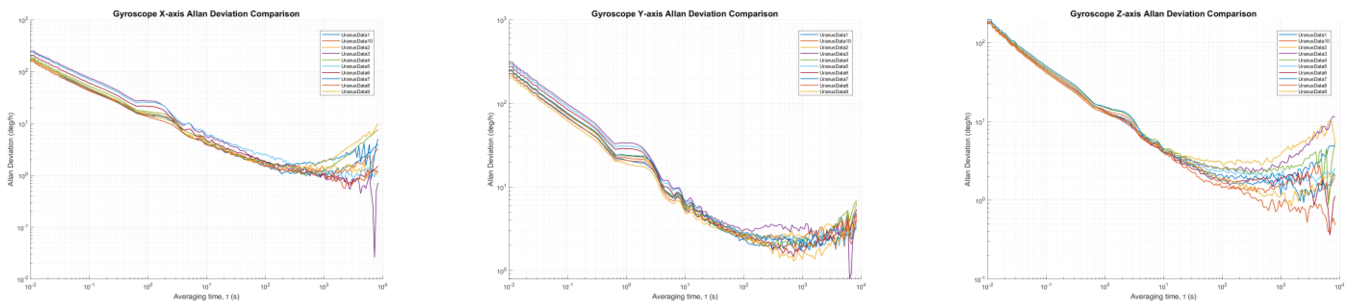


Figure 3: HI15R2 Gyroscope Allan Variance

9.2 Accelerometer

Table 10: Accelerometer Specifications

Parameter	Condition	Min	Typ	Max	Unit	Remark
Full Scale Range			±3 ±6 ±12 ±24		g	Default: ±12
Resolution			16		bit	
Initial Bias			1	2	mg	Typ: RMS
Nonlinearity			±0.5		%FS	1
Noise Density	Bandwidth 47 Hz		0.09	0.12	mg/√Hz	
3 dB Bandwidth			90	200	Hz	2
Sample Rate			1000		Hz	
Bias Instability Allan Variance	X Y Z		0.015 0.02 0.015	0.02 0.045 0.02	mg	Typ: 1σ Max: 3σ
Bias Stability 10 s averaging	X Y Z		0.06 0.055 0.05	0.1 0.15 0.06	mg	Typ: 1σ Max: 3σ
Bias Repeatability	X Y Z		0.127 0.09 0.07	0.25 0.15 0.15	mg	
Velocity Random Walk (VRW) Allan Variance	X Y Z		0.09 0.055 0.019	0.11 0.065 0.03	m/s/√h	Typ: 1σ Max: 3σ
Bias Change Over Temperature	-40 °C to 85 °C		2.5	5	mg	3

Note 1: Maximum deviation from the best-fit straight line within the specified range.

Note 2: Different modes have different bandwidths; the default 6-DoF mode bandwidth is 90 Hz.

Note 3: Measured using a thermal chamber and rate table in the Hipnuc laboratory, with a temperature ramp rate of less than 3 °C/min.

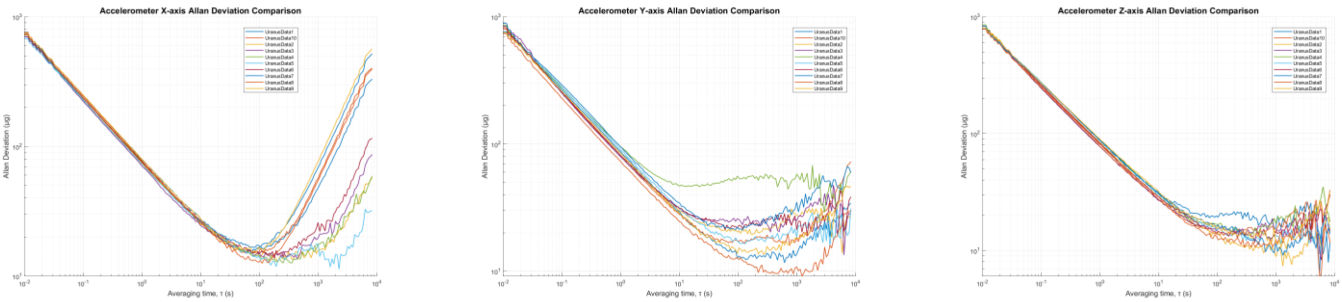


Figure 4: HI15R2 Accelerometer Allan Variance

9.3 Temperature Sensor Specifications

Table 11: Temperature Sensor Specifications

Parameter	Condition	Min	Typ	Max	Unit	Note
Range		-40	-	85	°C	
Offset Error			±5		°C	

9.4 Fusion Accuracy

Unless otherwise specified, the following attitude accuracy values are measured after factory calibration under typical installation conditions. Actual performance depends on installation flatness, mechanical stress, vibration, linear acceleration, magnetic environment, and user calibration status.

Table 12: Attitude Accuracy

Parameter	Condition	Min	Typ	Max	Unit	Note
Pitch/Roll (Static)			0.1	0.15	°	1
Pitch/Roll (Dynamic)			0.2	0.3	°	
Static Heading Drift (6-DoF)	Static for 2 h, accumulated drift		0.15	0.2	°	
Heading Rotation Error (6-DoF)	100 °/s rotation		<0.2	0.3	°	2

Note 1: Data are referenced to the calibration plane and derived from tests on 20 samples.

Note 2: Average error per revolution when the module rotates 10 cycles on a turntable.

10 System and Electrical Specifications

10.1 Electrical Specifications

Table 13: Electrical Specifications

Parameter	Min	Typ	Max	Unit	Note
Operating Voltage Range, VDD	6	-	36	V	
Power Consumption	1	1.2	1.3	W	

10.2 System Specifications

Table 14: System Specifications

Parameter	Value	Note
Dimensions	39.15 × 36 × 13 mm	
Weight	<25 g	
System Start-up Time	2 s	1
Operating Temperature	-40 °C to 85 °C	
Shield Material	Aluminum alloy	
Vibration Resistance	1.0 mm (10 Hz–58 Hz) / ≤20 g (58 Hz–600 Hz)	
Compliance Information	Compliant with RoHS requirements; EMC and CE compliance documents are available upon request	
Drop Test	Free fall from a laboratory bench height of 75 cm, repeated 3 times	
Temperature Shock Test	Temperature changes from -40 °C to 85 °C within 1 h, for a total of 5 cycles	
Moisture Sensitivity Level (MSL)	MSL 2	

Note 1: Time from power-on to valid data output.

10.3 Absolute Maximum Ratings

Table 15: Absolute Maximum Ratings

Parameter	Limit	Comment
Mechanical Shock	2000 g	Duration <0.2 ms
Storage Temperature	-40 °C to 125 °C	
ESD (HBM)	15 kV	JEDEC/ESDA JS-001
Input Voltage	40 V	

Note 1: Exceeding the absolute maximum ratings may cause permanent damage to the device. Functional operation at these conditions is not guaranteed.

11 Mechanical Dimensions

All dimensions are in mm

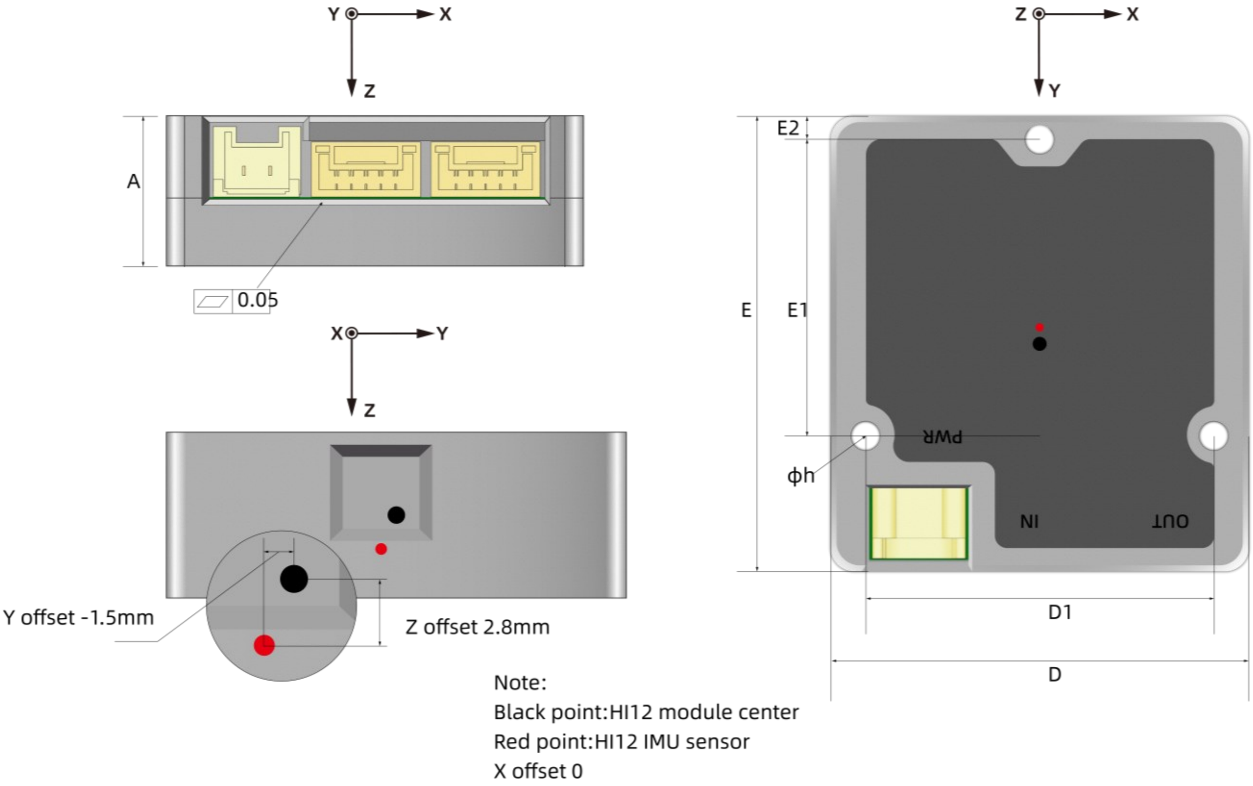


Figure 5: HI15 Mechanical Dimensions and IMU Location

Table 16: HI15 Mechanical Dimension Table

Symbol	Min (mm)	Typ (mm)	Max (mm)
A	12.8	13	13.2
D	35.9	36	36.1
D1	29.9	30	30.1
E	39.05	39.15	39.25
E1	25.4	25.5	25.6
E2	1.8	2	2.2
H	Φ2.55	Φ2.6	Φ2.65

12 Coordinate System

12.1 ENU (Default)

The body frame adopts the Right-Forward-Up (RFU) coordinate system, and the geodetic frame adopts the East-North-Up (ENU) coordinate system. The axes of acceleration and gyroscope are shown in the figure below:

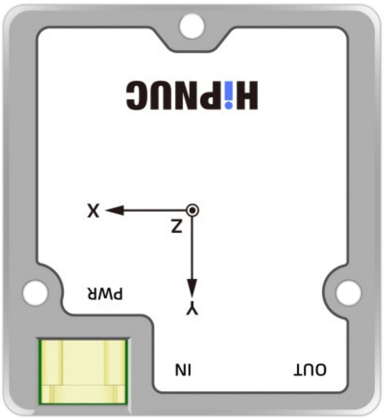


Figure 6: HI15R2-ECAT-000 Coordinate System

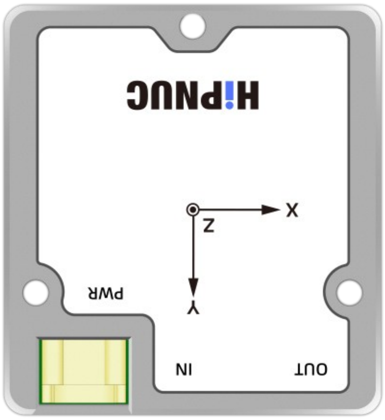


Figure 7: HI15R2-ECAT-010 Coordinate System

The Euler-angle rotation sequence follows the ENU 3-1-2 convention, i.e., rotation about the Z-axis first, followed by the X-axis, and then the Y-axis. The specific definitions are as follows:

- Rotation around the Z-axis: Heading Angle (Yaw, ψ); Range: -180° - 180°
- Rotation around the X-axis: Pitch Angle (θ); Range: -90° - 90°
- Rotation around the Y-axis: Roll Angle (ϕ); Range: -180° - 180°

When the module is interpreted using an aircraft convention, the positive Y-axis corresponds to the forward direction. When the sensor frame coincides with the inertial frame, the ideal output of Euler angles is: Pitch = 0°, Roll = 0°, Yaw = 0°.

For coordinate system rotation, please refer to the Command and Programming Manual

12.2 NWU and NED

The body frame can also be configured to the North-West-Up (NWU) or North-East-Down (NED) coordinate system. Users need to configure it independently. For details, refer to the Command and Programming Manual

13 Installation

Recommended installation method for the HI15 is as follows:

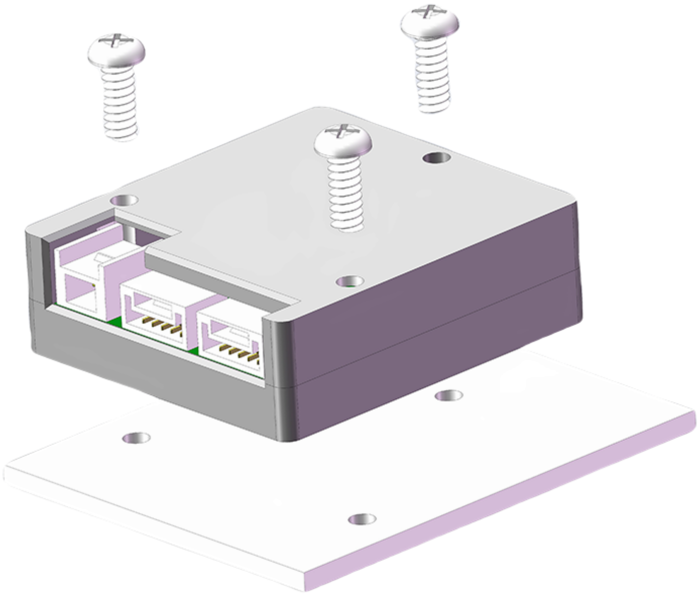


Figure 8: Installation Illustration

1. Rigidly fix the bottom of the HI15 to the target carrier
2. The mounting surface should be as flat and rigid as possible
3. Avoid installation near strong heat sources
4. Avoid continuous stress on the module caused by cable pulling
5. For vibration applications, actual system-level verification testing is recommended

14 Communication Protocol

IMU data is output through the EtherCAT TxPDO channel.

14.1 Overview of Object Structure

- **0x6000**: IMU data object, defining the actual transmitted data, including acceleration, angular rate, quaternion, and status information
- **0x1A00**: TxPDO mapping object, mapped from the subentries of 0x6000
- **0x1C13**: SyncManager 3 assignment object, pointing to 0x1A00

The master reads the mapped entries configured in 0x1A00 through SyncManager 3, and thus receives real-time IMU data from 0x6000.

14.2 Structure of Object 0x6000

Table 17: Object 0x6000 Data Structure

Subindex	Name	Data Type	Description
0x01	acc_x	REAL32(float)	X-axis acceleration, unit: m/s^2
0x02	acc_y	REAL32(float)	Y-axis acceleration, unit: m/s^2
0x03	acc_z	REAL32(float)	Z-axis acceleration, unit: m/s^2
0x04	gyr_x	REAL32(float)	X-axis angular rate, unit: rad/s
0x05	gyr_y	REAL32(float)	Y-axis angular rate, unit: rad/s
0x06	gyr_z	REAL32(float)	Z-axis angular rate, unit: rad/s
0x07	qw	REAL32(float)	Quaternion W
0x08	qx	REAL32(float)	Quaternion X
0x09	qy	REAL32(float)	Quaternion Y
0x0A	qz	REAL32(float)	Quaternion Z
0x0B	temperature	REAL32(float)	Average module temperature, unit: °C
0x0C	system_time	UINT32	Local timestamp since power-on, incremented by 1 ms

14.3 FoE Firmware Upgrade

Firmware upgrade is supported via FoE.

1. Switch the device to BOOT mode.
2. Enter password 0x48493135.
3. Import the firmware upgrade file (.bin). The corresponding upgrade file is provided by Hipnuc technical support based on the firmware version.

Note 1: After the upgrade, upon first power-on, wait about 15 seconds for firmware integrity verification and loading.

Note 2: If power is interrupted during the waiting process, the device will still require about 15 seconds for firmware integrity verification on the next power-up.

15 Disclaimer

The parameters provided in this document are typical values, maximum values, or measured values obtained under specified test conditions and do not constitute binding product specifications or delivery commitments. Hipnuc reserves the right to modify the product, this document, and related information without prior notice.