# 1 FEATURES

1.1 Hardware

- High-performance, low-noise MEMS-IMU
- Integrated low-noise, high-reliability LDO
- Factory-calibrated scale factor, cross-axis, and bias

(contact sales for temperature compensation requirements)

- Excellent vibration resistance
- Integrated temperature sensor
- Compact surface-mount package: 15x15x2.6mm, easy to integrate
- Compliant with RoHS, CE, and Halogen-free certifications

1.2 Software

- Adaptive Extended Kalman Filter (EKF) fusion algorithm, up to 200Hz output, low latency
- Exceptional linear acceleration suppression
- Customizable binary protocol
- Rich user configuration commands
- Multi-functional GUI for easy operation
- Supports multiple programming examples, including ROS1, ROS2, C, Matlab, Python, and Arduino
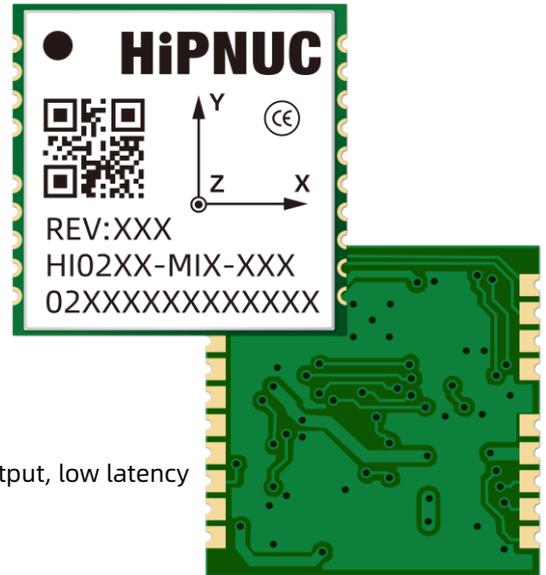
2 APPLICATIONS

The HI02 series is specifically designed to meet cost-sensitive application requirements:

- Robotic vacuum cleaners
- Lawn mowers
- Pool cleaning robots

3 GENERAL DESCRIPTION
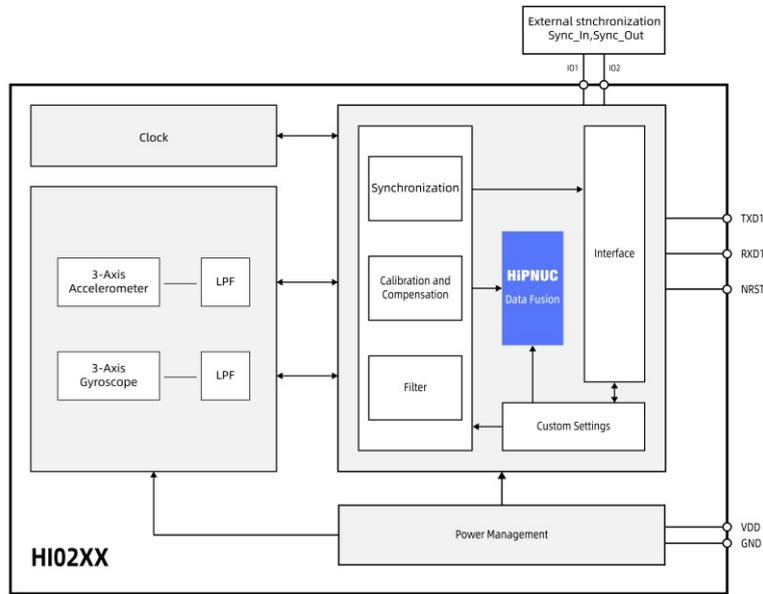
3.1 System Block Diagram

Figure1: HI02 3.1 System Block Diagram

3.2 Description

The HI02 series is an IMU/VRU sensor based on MEMS-IMU technology. It features proprietary algorithms, including an adaptive extended Kalman filter, dynamic IMU noise analysis, and carrier motion state analysis, providing users with precise attitude information.

Each sensor undergoes compensation and calibration before leaving the factory, including bias, scale factor, and cross-axis calibration. The module supports data transmission via a UART interface.

The multi-functional GUI (Graphical User Interface) facilitates quick product evaluation, offering features such as module configuration, data visualization, firmware upgrades, and data logging, among others.

Figure2: GUI

CONTENT

4 SELECTION

Table 1: Model Information

HI02a-b-c[1]						
Company	Series	a-Sensor		b-Interface		c-OEM
HI	02	M0	IMU/VRU	MI0		000 Default

Note1: HI02M0-MI0-000

5 ORDERING

5.1 Ordering Information

Table 2: Ordering Information

Part Number	Name	Description	Note
HI02M0-MI0-000	IMU/VRU Module	IMU/VRU	

5.2 Contact Us

1. Email: overseas1@hipnuc.com

2. web: www.hipnuc.com

www.hipnuc.com

6 DOCUMENT

6.1 Revision History

Table 3: Revision History

Revsion	Date	Section	Changes
1.0	5/31/2025	-	Initial
1.1	2/10/2026	All	Modify the product appearance and rearrange the document layout

6.2 Related Documents and Development Kits

1. Command and Programming Manual

2. 3D Step

3. Evaluation Board EVAL HI02XX Data Sheet and Design Files

4. CE/RoHS

5. GUI and Reference Examples

7 SYSTEM ARCHITECTURE

The HI02 series is a sensor module that integrates multiple functions of IMU and VRU. It undergoes rigorous calibration and testing for scale factor, cross-axis, and bias before leaving the factory, providing users with fundamental sensor data (acceleration, angular velocity), three-dimensional orientation data (Euler angles including pitch, roll, and yaw), and quaternion data.

The HI02 module is equipped with a 3-axis accelerometer, a 3-axis gyroscope, and a high-performance processor. This controller is primarily used for sensor synchronization, calibration, algorithm fusion, and user configuration.

7.1 IMU Subsystem

The HI02 can be used as an Inertial Measurement Unit (IMU), providing users with precise three-dimensional acceleration and angular velocity data. This data is collected through internally integrated high-precision accelerometers and gyroscopes, enabling real-time reflection of an object's motion and dynamic changes in three-dimensional space. Compared to traditional IMU chips, the notable advantage of the HI02 lies in its rigorous calibration and compensation adjustments performed before leaving the factory, significantly improving the accuracy and stability of the output data. These calibrations include cross-axis, scale factor, and bias corrections.

7.2 VRU Subsystem

The HI02, leveraging our proprietary algorithm fusion engine, is capable of deeply processing and optimizing the fundamental IMU data to output high-precision three-dimensional orientation data based on the gravity reference frame. This orientation data includes pitch, roll, and yaw angles, providing users with intuitive and reliable attitude information support..

8 PIN DEFINITIONS
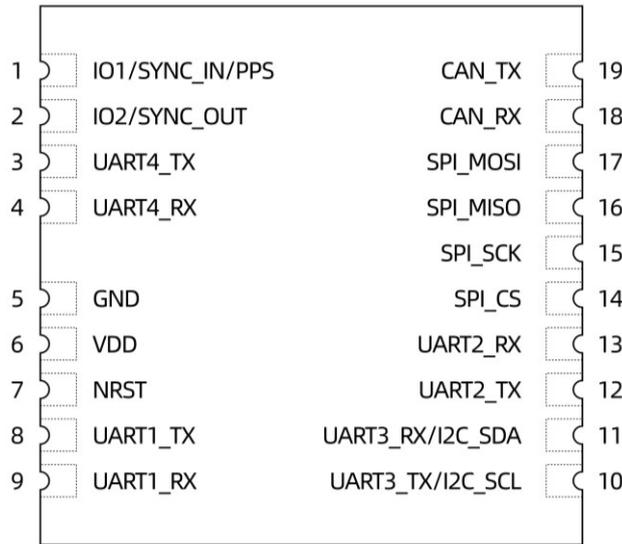
Figure3: HI02XX-MI0 Pin Definitions

Table 4: Pin Functional Definitions

Pin Number	Pin Name	Type	Functional	Note
1	IO1(SYNC_IN)	I/O	Synchronization input; can accept external trigger signals	
2	IO2(SYNC_OUT)	I/O	Synchronization output; can be used as a Data Ready signal	
3,4,10,11,14,15, 16,17,18,19	NC	N/A	Reserved	
5	GND	Power	Power Ground	
6	VDD	Power	Module power input: 3.3~5V	
7	NRST	I	Reset pin; active-low reset for the module. It is recommended to connect to the host GPIO; leave floating if not used	
8	UART1_TX	I/O	Module UART1 transmit	
9	UART1_RX	I/O	Module UART1 receive	
12	UART2_TX	I/O	Module UART2 transmit Currently floating	
13	UART2_RX	I/O	Module UART2 receive Currently floating	

9 INTERFACE AND REFERENCE DESIGNS

9.1 Power Supply

The HI02 series sensors integrate a Low-Dropout Regulator (LDO), which plays a critical role in power management. The integration of LDO can effectively reduce the interference of external power supply noise on the internal system of the module, thereby improving the stability and reliability of the system. This optimized design enables the HI05 to maintain high-precision performance output even in complex power supply environments. Therefore, users can power the system with an LDO or DCDC converter, with a voltage range of 3.3-5V.
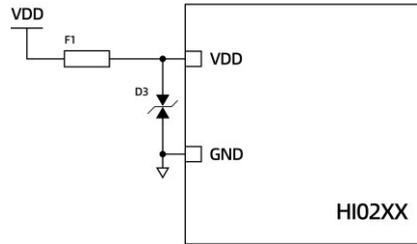

Figure4: HI02 Power Supply Reference Design

9.2 UART

The HI02 series sensors support flexible and diverse communication methods and can communicate via UART1 in full-duplex mode. By default, the communication frame format follows the standard N8N1 mode, which is specified as follows：

    Baud rate：115200 bps（adjustable as needed）

    Data Bits：8 bits

    Parity: (No parity)

    Stop bits: 1 bit

This communication configuration is a standard in industrial applications, offering strong compatibility and seamless integration with most embedded systems, industrial control equipment, and robot controllers. Additionally, the HI02 can be connected to external RS-232/RS-485/RS-422 transceivers to extend the UART interface into RS-232/RS-485/RS-422 communication modes, further enhancing the module's versatility and scalability.

Note1: Both the baud rate and data transmission frame rate can be modified via commands. For details, please refer to the command and programming manual.

When using the HI02 series sensor for serial communication, it is recommended that the logic level of the user's processor is 3.3V. If communication with processors using 5V or 1.8V logic levels is required, users need to add a level-shifting chip to ensure communication reliability and device safety.
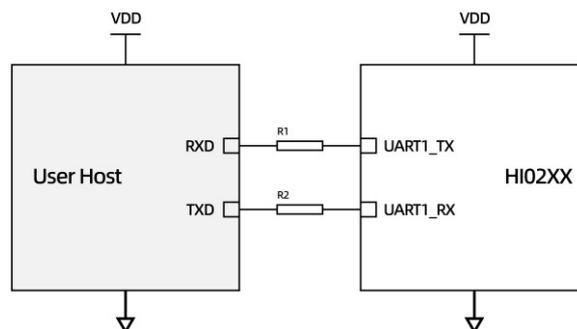

Figure5: Minimum System for HI02 UART Communication

9.3 Synchronization System

The HI02 supports a pulse trigger function, allowing synchronization with the user's system.
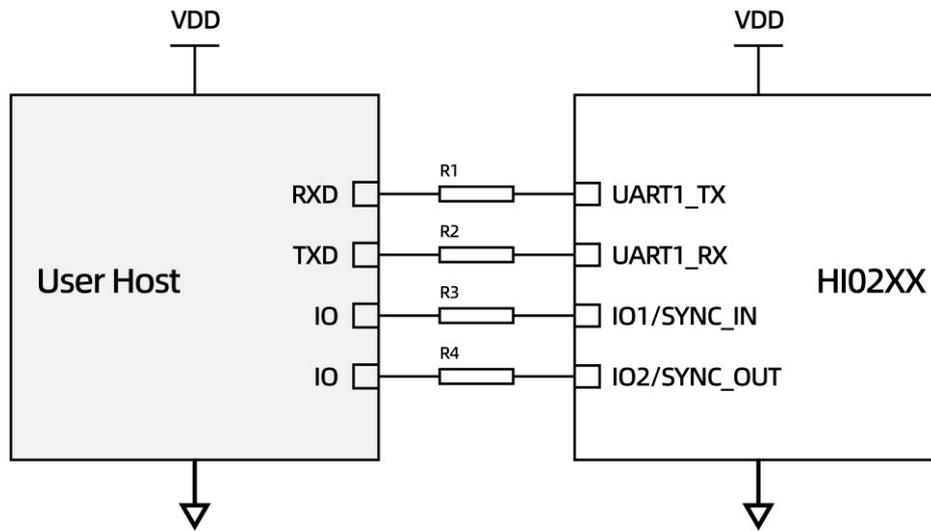

Figure6: HI02 Host-Triggered Synchronization (UART Communication)

This connection method requires users to directly connect IO1/IO2 to the host system for inter-system trigger synchronization. If users use IO1 for synchronization input, IO1 will be set to synchronization input mode, and the host needs to generate pulses with the same frequency as the data frame rate and send them to the HI05. If users use IO2, IO2 needs to be set to synchronization output mode; the synchronously output pulses have the same frequency as the data frame rate and can be used as a Data Ready signal. IO1 and IO2 do not need to be used simultaneously; users can select the appropriate synchronization method according to their own system requirements.

9.4 Reference Design BOM

Table 5: Reference Design BOM

Item	Reference	Part	P/N	Vendor
Fuse	F1	300mA	JK-SMD0603-030-6	JK
TVS	D3	SMF5.0CA	SMF5.0CA	LittleFuse
Resistor	R1,R2,R3,R4	1K	RC0402JR-071KL	YAGEO

Note1: The 1K resistor can be adjusted according to the user's actual scenario. For long transmission distances, the resistance can be reduced to 33Ω or 100Ω if needed.

10 SPECIFICATIONS

10.1 Gyroscope

Table 6: Gyroscope Parameters

Parameters	Condition		Min	Typ	Max	Unit	Note
Range			±15.625	±2000	±4000	°/s	
Resolution				16	20	bit	
Scale Factor	100°/s Before SMT			250	400	ppm	Typ:RMS
	100°/s After SMT			1390	2225		
Nonlinearity				±0.05		%Fs	1
Noise Density	47Hz			0.014		°/s√Hz	
3dB Bandwidth				80	200	Hz	
Zero-Rate Output				<0.1	±0.45	°/s	2
Sampling Rate				1000		Hz	
Bias Instability	Allan Variance	X		2.5	4	°/h	Typ:1σ
		Y		3.2	5.5		Max: 3σ
		Z		3	5.5		
Bias Stability	10s Average	X		10	14	°/h	Typ:1σ
		Y		13	17		Max: 3σ
		Z		10	13		
Bias Repeatability		X		20	36	°/h	3
		Y		36	61		
		Z		16	25		
Angle Random Walk (ARW)	Allan Variance	X		0.55	1.1	°/√h	Typ:1σ
		Y		0.82	1.2		Max: 3σ
		Z		0.47	0.7		
Bias Temperature Drift	-40-85℃			0.07	0.15	°/s	4
Accelerometer Sensitivity	All three axis			0.05		°/s/g	

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

Note2: After initial bias calibration, the bias can be estimated in real time by the algorithm engine.

Note3: The module is powered on for 20 minutes, then data is collected for 300s; power off for 5s, power on again and collect data. Repeat this process 10 times.

Note4: Temperature compensation is not enabled by default. Please contact the sales representative if needed.Tested on the temperature chamber turntable of HiPNUC Laboratory, with a temperature rise rate less than 3℃/min.
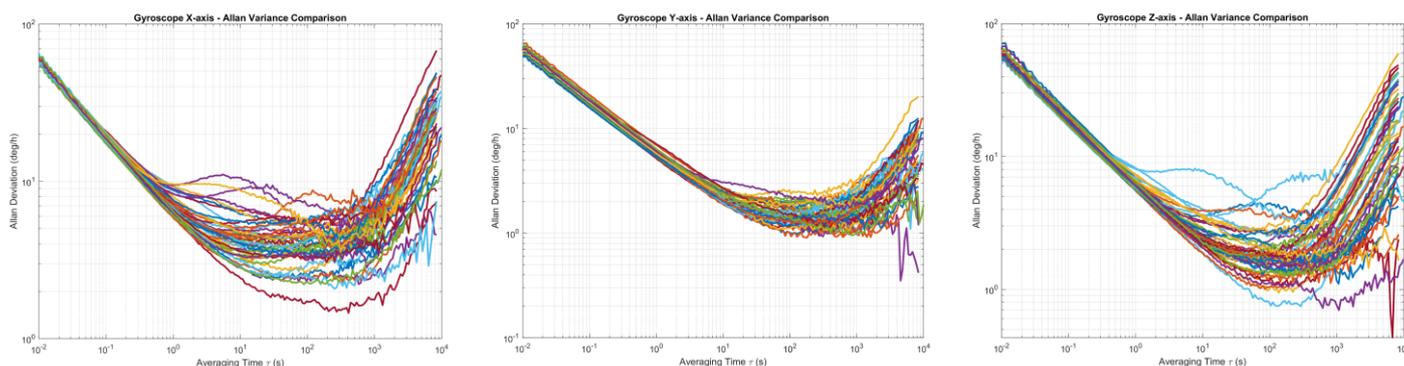

Figure7: Gyroscope Allan Variance

10.2 Accelerometer

Table 7: Accelerometer Parameters

Parameters	Condition		Min	Typ	Max	Unit	Note
Range			±2	±12	±24	g	
Resolution				16		bit	
Initial Bias	Before SMT, Keep horizontally stationary			1	2	mg	Typ:RMS
	After SMT: Keep horizontally stationary			3	20		
Nonlinearity				0.01		%Fs	1
Noise Density				90	200	Hz	
3dB Bandwidth				0.16	0.2	mg/√Hz	
Sampling Rate				1000		Hz	
Bias Instability	Allan Variance	X		0.021	0.035	mg	Typ:1σ Max: 3σ
		Y		0.032	0.065		
		Z		0.023	0.03		
Bias Stability	10s Average	X		0.068	0.1	mg	Typ:1σ Max: 3σ
		Y		0.09	0.19		
		Z		0.07	0.1		
Bias Repeatability		X		0.22	0.4	mg	2 Typ:1σ Max: 3σ
		Y		0.15	0.21		
		Z		0.12	0.2		
Random Walk (ARW)	Allan Variance			0.09	0.11	m/s/√h	Typ:1σ Max: 3σ
Bias Temperature Drift	-40-85℃	XY		2	5	mg	3
		Z		6	15		

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

Note2: he module is powered on for 20 minutes, then data is collected for 300s; power off for 5s, power on again and collect data. Repeat this process 10 times.

Note3: Temperature compensation is not enabled by default. Please contact the sales representative if needed.Tested on the temperature chamber turntable of HiPNUC Laboratory, with a temperature rise rate less than 3℃/min.
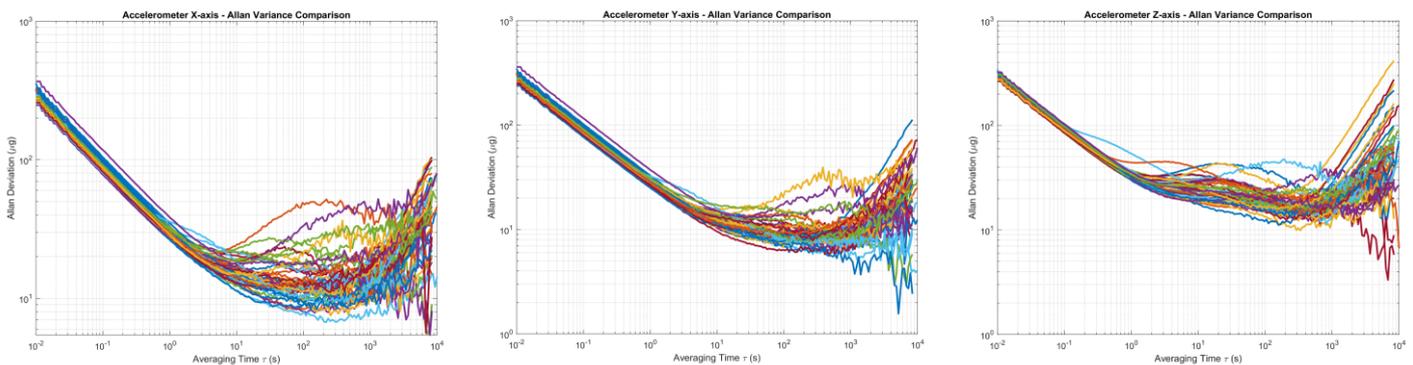

Figure8: Accelerometer Allan Variance

10.3 Temperature Sensor

Table 8: Temperature Sensor Prameters

Parameters	Condition	Min	Typ	Max	Unit	Note
Range		-40	-	85	℃	
Offset error			±5		℃	

10.4 Fusion Accuracy

Table 9: Attitude Angle Accuracy

Parameters	Condition	Min	Typ	Max	Unit	Note
Pitch/Roll (Static)	Before SMT		0.1	0.15	°	1
	After SMT		0.4	1		
Pitch/Roll (Dynamic)	Before SMT		0.2	0.3	°	
	After SMT		0.5	1		
Heading Angle Static Drift (6DOF)	Static for 2h		0.15	0.2	°	
Heading Angle Dynamic Drift (6DOF)			<±10	±18	°	2
Heading Angle Rotation Error (6DOF)	100°/s rotation, Before-SMT		0.1	0.3	°	3
	100°/s rotation, After-SMT		0.5	1.2		

Note1: Data is referenced to the calibration plane; derived from tests on 20 pcs of samples.

Note2: Measured during 1h of operation on an indoor cleaning robot; 1σ

Note3: Average error per revolution when the module rotates 10 cycles on a turntable.

11 SYSTEM AND ELECTRICAL

11.1 Electrical Specifications

Parameters	Condition	Min	Typ	Max	Unit	Note
Input Voltage VDD		3.2	-	5.5	V	
Power Consumption				150	mW	
V_{OL}			-	0.4	V	
V_{OH}		2.6			V	
V_{IL}		-0.3		1	V	
V_{IH}		1.9		3.6	V	

11.2 Interface

Interf	Parameters	Min	Typ	Max	Unit	Note
UART1	Baud Rate	9600	115200	921600	bps	
	Output Frame Rate	0	100	200	Hz	

11.3 System Parameters

Parameters	Product	Value	Note
Dimensions		15X15X2.6mm	
Weight		<1.5g	
System Start-up Time		2s	1
Operating Temperature		-40-85℃	
Shield Material		Cupronickel	
Vibration Resistance		1.0mm(10Hz-58Hz)&≤20g(58Hz-600Hz)	
Environmental Compliance		RoHS 指令 2011/65/EU	
EMC		LVD Directive 2014/35/EU	
Drop Test		free-fall drops from a 75 cm-high test bench	
Temperature Shock Test		cycles of temperature rise from -40℃ to 85℃ within 1 hour	
Moisture Sensitivity Level (MSL)		MSL2	

Note1: Time from power-on to valid data output.

11.4 Absolute Maximum Ratings

Parameters	Limit	Comment
Mechanical Shock	10,000g	Duration <0.2ms
Storage Temperature	-40℃-125℃	
ESD HBM	2KV	JEDEC/ESDA JS-001
Input Voltage	6V	
IO To GND	-0.3-5V	

12 MECHANICAL
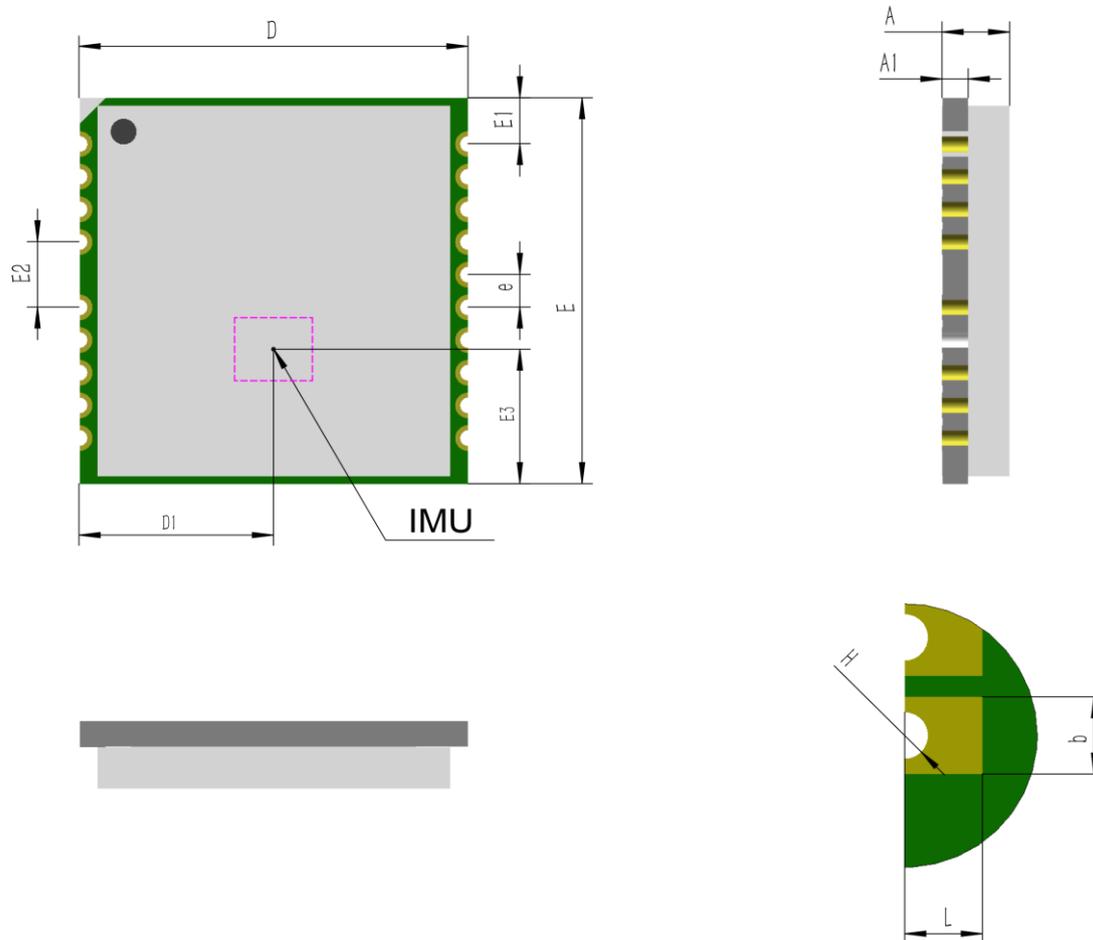
All Dimensions in mm units

12.1 HI02 Mechanical Dimensions

Figure9: HI02 Mechanical Dimensions and IMU Position

Table 10: HI02 Mechanical Dimensions

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	2.5	2.6	2.7
A1	0.95	1	1.05
D	14.8	15	15.2
D1	7.45	7.5	7.55
E	14.8	15	15.2
E1	1.69	1.79	1.89
E2	2.5	2.54	2.55
E3	4.9	5	5.1
e	1.25	1.27	1.28
L	0.95	1	1.05
b	0.87	0.9	0.92
H	R0.26	R0.27	R0.28

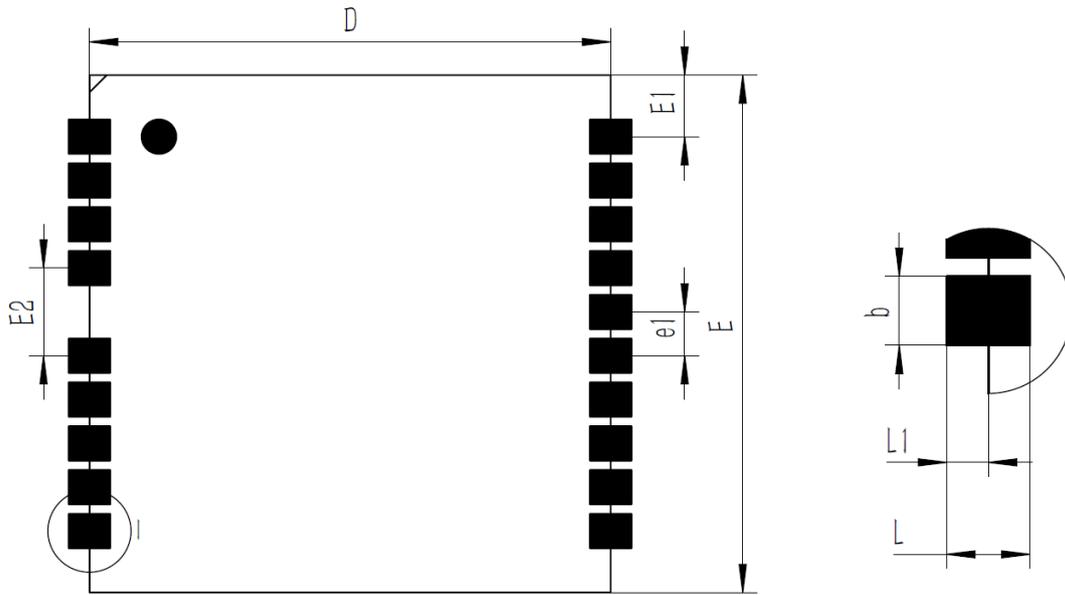## 12.2 Recommended Package Dimensions

Figure10: HI02 Recommended Package Dimensions

Note1: Exposed copper traces are prohibited on the back of the device.

Table 11: HI02 Recommended Package Dimension

Symbol	Min(mm)	Typ(mm)	Max(mm)
D		15	
E		15	
E1		1.79	
E2		2.54	
e		1.27	
b		0.9	
L		2	
L1		1	

13 COORDINATE SYSTEM

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:
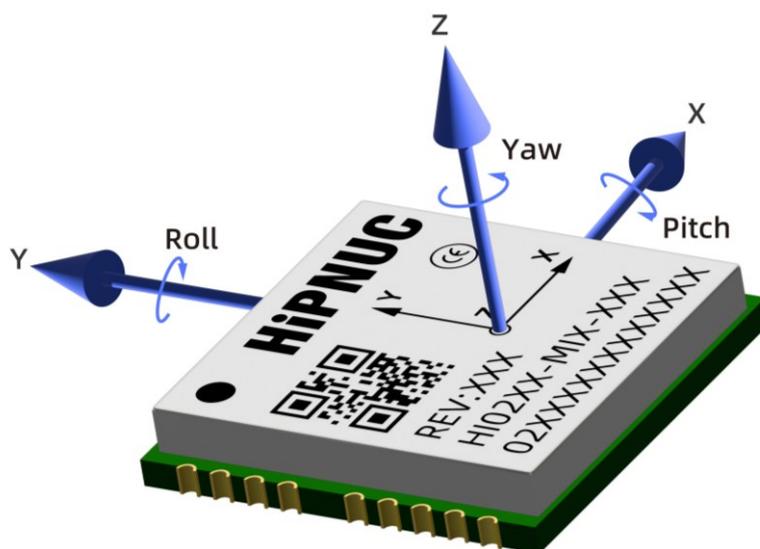

Figure11: HI02 Coordinate System

The Euler angle rotation sequence follows the East-North-Up 312 rule (rotate around the Z-axis first, then the X-axis, and finally 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°

If the module is regarded as an aircraft, the positive direction of the Y-axis should be taken as the nose 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.

14 EVALUATION BOARD

EVAL HI02 is a simplified evaluation board designed for quickly evaluate HI02 series attitude sensors. It has a Molex connectors J1 for communication with host devices via compatible USB-to-Molex cables or OPEN wiring harnesses. The EVAL HI02 must be rigidly mounted to user equipment during operatio
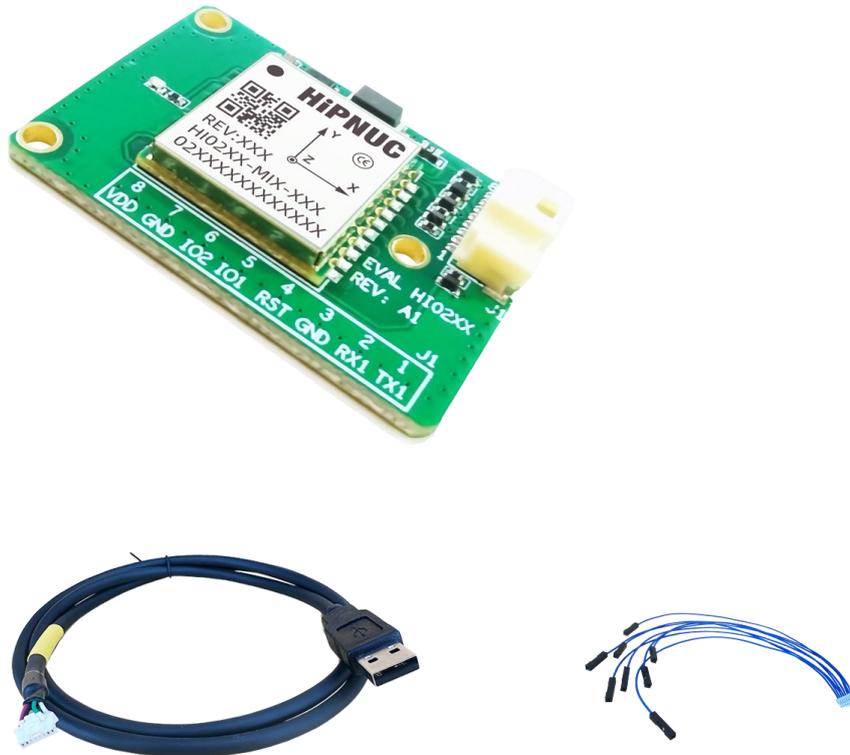

Figure12: HI02 Series Evaluation Board and Cable

Note1: The USB-to-Molex wiring harness has a length of 1 m, and the Molex-to-Dupont terminal wiring harness has a length of 30 cm.

15 PROTOCOLS

For user convenience, we provide a customizable binary serial protocol for selection. For more details, please refer to the command and programming manual.
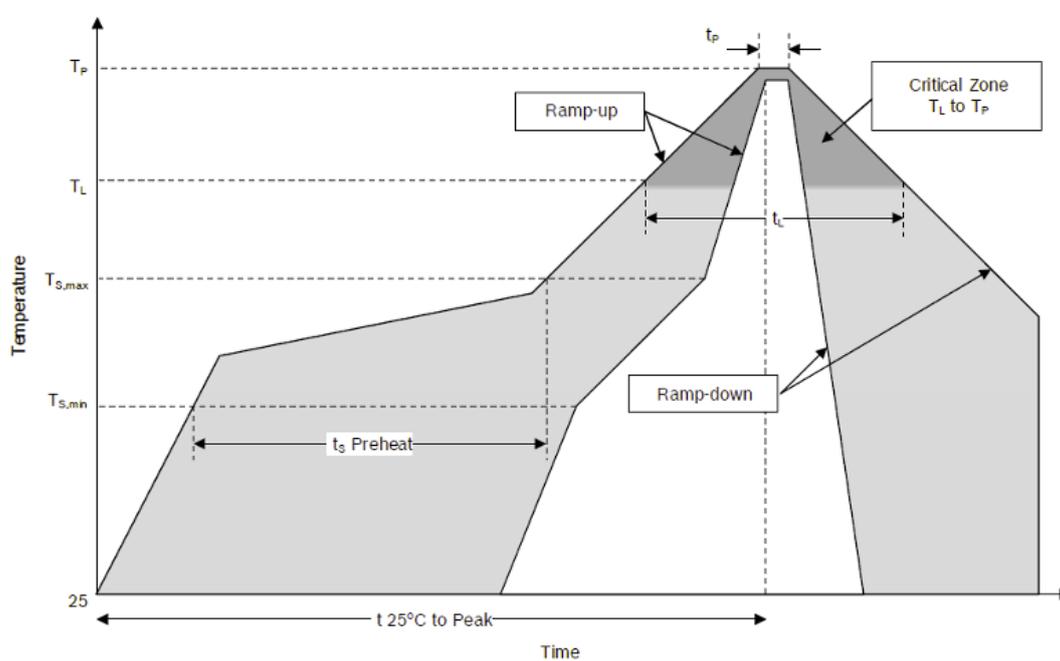
16 SMT AND INSTALLATION

16.1 SMT Temperature Profile

Figure13: SMT Temperature Profile

Table 12: SMT Temperature Profile Descriptions

Parameters	Descriptions
Average ramp-up rate (T_{Smax} to T_p)	3℃/s max
Temperature min (TSmin)	150℃
Temperature max (T_{Smax})	200℃
Time (TSmin to TSmax)	60-180s
Temperature (T_L)	170℃
Time (tL)	60-150s
Peak classification temperature (T_P)	250℃
Time within 5 ℃ of actual peak temperature (tp)	20-40s
Ramp-down rate	6℃/min max
Time 25°C to peak temperature	8min max

16.2 Install Recommendations

Generally speaking, MEMS sensors are high-precision measuring devices composed of electronic and mechanical structures, designed for accuracy, efficiency and mechanical robustness. When mounting the sensor on a Printed Circuit Board (PCB), the following recommendations should be considered:

- It is recommended to mount the module horizontally on the measured carrier.上

- It is not recommended to place the sensor directly under or next to button contacts, as this will cause mechanical stress.

- It is not recommended to place the sensor directly near high-temperature hotspots (e.g., controllers or graphics chips), as this will cause rapid temperature rise of the PCB and thus heat up the sensor.

- It is not recommended to place the sensor near areas with maximum mechanical stress (e.g., at the center of diagonal intersections). Mechanical stress can cause bending of the PCB and the sensor.

- It is not recommended to mount the sensor too close to screw holes. Avoid mounting the sensor in areas where the PCB may or is expected to resonate (vibrate).

If the above recommendations cannot be properly implemented, specific in-line offset calibration after placing the device on the PCB may help minimize potential impacts.
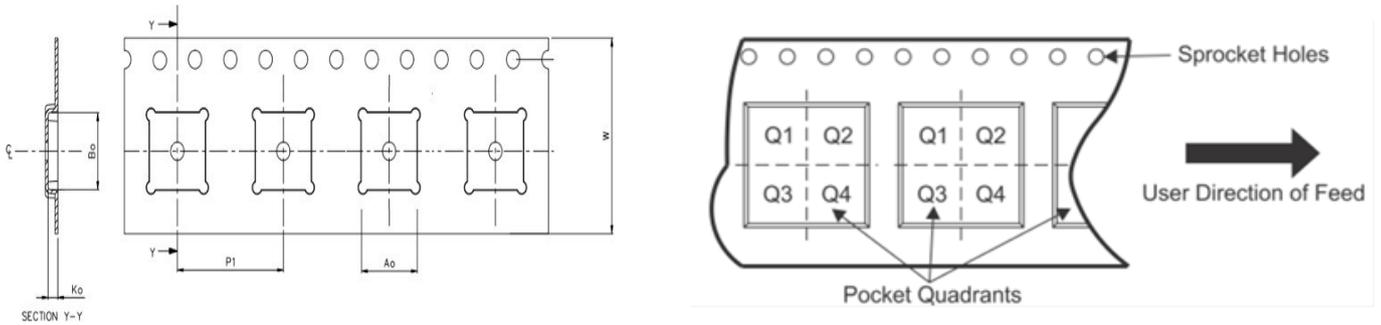
17 PACKAGING

17.1 Tape

Figure14: Tape Dimension and pin 1

Table 13: Tape Dimension Information

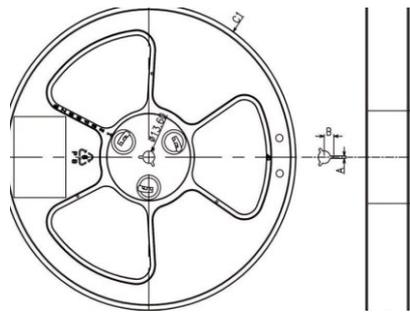| Device	A0(mm)	B0(mm)	K0(mm)	P1(mm)	W(mm)
HI02	15.4	15.4	2.9	20	24

17.2 Reel

Figure15: Reel Dimension

Table 14: Reel Dimension Information

Device	SPQ(PCS)	Reel Diameter C1(mm)	Reel Width H(mm)	A(mm)	B(mm)	T(mm)	D(mm)
HI02	1000	330	16.8	2.5	11	2.0	100

17.3 Packaging Method

The HI02 series is packaged in standard cartons.
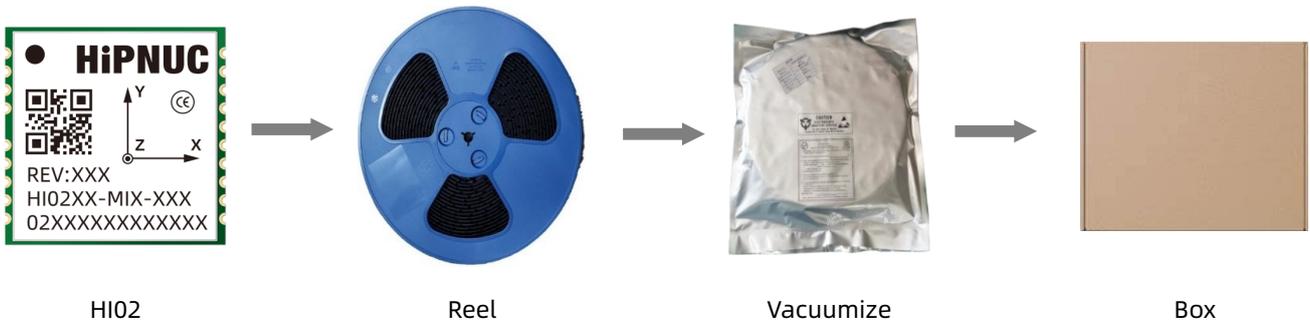
Table 15: Packing Configuration

| HI02 | Reel | Vacuumize | Box |

Table 16: Carton Dimensions

Device	SPQ(PCS)	L(mm)	W(mm)	H(mm)
HI02XX	1000	360	360	40