1 Features

1.1 Hardware

- High-performance MEMS IMU
- Factory-calibrated over -40°C to +85°C with full-temperature compensation; calibrated scale factor, cross-axis sensitivity, and bias
- Gyroscope bias instability down to 1.6°/h
- Accelerometer bias instability down to 18 μg
- Fully symmetrical design
- Multi-function I/O signals (including but not limited to sync input/output and alarm functions)
- Excellent vibration resistance
- Integrated temperature sensor
- Compact SMD package for easy integration
- RoHS and CE certified

1.2 Firmware/Software

- Adaptive EKF fusion algorithm, up to 1000 Hz output with low latency
- Excellent dynamic tracking with strong vibration suppression
- Excellent suppression of linear acceleration effects
- Start-up time < 1 s
- Supports multiple protocols including binary, CANopen, and Modbus
- Outputs data immediately without external configuration commands
- Rich set of user configuration commands
- Multi-function GUI for easy operation
- Reference examples available for ROS, C, Qt, and more

2 Applications

- Precision instruments and measurement equipment
- Platform stabilization and control
- Construction/industrial machinery
- Underground/mining instrumentation
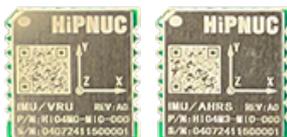- Low-speed autonomous robots

3 Description

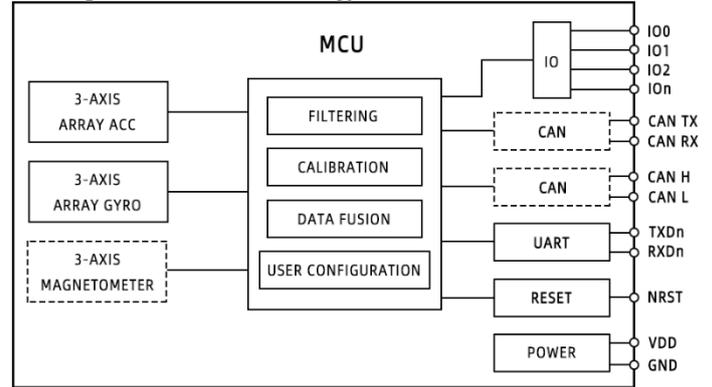## 3.1 Product appearance

Figure1: HI04

3.2 System block diagram

Figure2: Functional block diagram

Note1: Dashed lines indicate features not supported by some models; see the model selection table (Table 1) for details.

3.3 General description

The HI04 series is an IMU/VRU/AHRS sensor built around a MEMS IMU. It integrates proprietary adaptive EKF fusion, IMU noise dynamic analysis, and platform motion-state analysis algorithms to maintain attitude accuracy under high dynamics and reduce heading drift.

Each unit is carefully compensated and calibrated at the factory, including temperature, bias, scale factor, and cross-axis terms.

The HI04 series transmits data via UART/CAN interfaces and provides extensive user configuration. If a CAN interface is required, the user must integrate an external CAN transceiver circuit.

The HI04 series can be synchronized to the host system via an external trigger, and it can also time-align external systems (e.g., radar or cameras) using its sync output functions.

The PC GUI enables rapid evaluation, including (but not limited to) module configuration, data display, firmware upgrade, and data logging.

For model selection and ordering information, see Table 1 and Table 2.Table 1

Table of Content

4 Model selection

Table 1: **Selection information**

HI04a-b-c[1]						
Company identifier	Product series	a – sensor		b – data interface		c – customization
HI	04	M0	6DoF 3°/h 30ug	MI0	UART	000 Default
		M3	6DoF 3°/h 30ug+Magnetic	MI1	UART+CAN 2.0	Other Customized

Note1: Example model: HI04M3-MI0-000
Note2: All models provide full-temperature compensation by default; supported by firmware v1.5.5 and later only.

5 Ordering information

5.1 **Ordering information**

Table 2: **Ordering information**

Part Number	Name	Description	Note
HI04M0-MI0-000	IMU/VRU Module	6DoF 3°/h UART	
HI04M3-MI0-000	IMU/AHRS Module	6DoF 3°/h +Magnetic UART	

5.2 **Contact us**

You may contact us by:

Tel: +886-2-89699610

Web: sealandtech.com.tw

Email: sltech@ms28.hinet.net

Line: SeaLandTech

6 Document information

6.1 Scope

This document applies to modules with hardware version A0 and above.

6.2 Document revision history

Table 3: File version

Version	Date	Section	Changes
1.0	Oct 23, 2024	-	Initial release
1.1	Nov 21,2024	7.13	Update package dimensions
1.2	Nov 27,2024	7.13 12	Update package dimensions and synchronization description
1.3	Dec 28,2024	4,5.1,7	Add HI04M3
1.4	Mar.3,2025	5.1,7.9,15	Add FAQ section and update Allan parameters

6.3 Related documents and development kits

1. *Command and programming manual*
2. *STEP/package files*
3. *EVAL HI04 evaluation board datasheet and design files*
4. *Certification files (CE/RoHS, etc.)*
5. *PC GUI and reference examples*
6. *HI04 series test report*

7 Specifications

Unless otherwise specified, tests are performed at 25°C with a 5 V supply.

7.1 Absolute maximum ratings

Table 4: Absolute maximum ratings

Parameters	Limit	Comment
Mechanical shock	2000g	Duration <1ms
Storage temperature	-40°C-85°C	
ESD HBM	2KV	JEDEC/ESDA JS-001
Input voltage	9V	
IO To GND	-0.3 to 5V	

7.2 Normal operating conditions

Table 5: Normal operating conditions

Parameters	Min	Nom	Max	Unit	Note
Input voltage	3.2	-	5.5	V	
Power consumption			160	mW	
Operating temperature	-40	-	85	°C	
Gyroscope full-scale range	125	2000	2000	°/s	
Accelerometer full-scale range	3	12	24	g	
Start-up time			2	s	1

Note1: Start-up time refers to the time from power-off to valid data output. Keep the module stationary during this period.

7.3 Interface parameters

Table 6: Interface parameters

Interf	Parameters	Condition	Min	Nom	Max	Unit	Note
UART(TTL)	Baud rate		9600	115200	921600	bps	
	Start bit		0	1		bit	
	Data length		0	8		bits	
	Stop bit			1		bit	
	Parity			None		bit	
	Output frame rate		0	100	1000	Hz	1
	Logic level	High	2.0	3.0	3.6	V	
		Low			0.6		
CAN	Baud rate		125	500	1000	kbps	2
	Output frame rate		5	100	200	Hz	3
	Logic level	High	2.0	3.0	3.6	V	
		Low			0.6		
IO	Logic level	High	2.0			V	
		Low			0.6	V	
	Latency (trigger function)	From trigger event to data transmission			800	us	4

Note1: Supported output rates: 1, 5, 10, 50, 100, 200, 250, 500, and 1000 Hz.
Note2: Supported CAN baud rates: 125K, 250K, 500K, and 1000K.
Note3: Supported CAN output rates: 5, 10, 50, 100, and 200 Hz.
Note4: For multi-function I/O operation and configuration, refer to the Command and Programming Manual.Command and programming manual

7. 4 **Gyroscope**

Table 7: **Gyroscope specifications**

Parameters	Condition	Min	Nom	Max	Unit	Note
Full-scale range			2000		°/s	
Resolution			16bit			
Scale factor	100°/s		<600	800	ppm	1
Non-linearity		-0.05	-	0.05	%Fs	2
3 dB bandwidth			47	116	Hz	
Sampling rate			1000		Hz	
Bias instability	Allan Variance		3		°/h	3
Bias stability	10 s smoothing		10		°/h	
Bias repeatability	Allan Variance		14.5		°/h	3
Angle random walk	Allan Variance		0.42		°/√h	3
Bias variation over temperature (-40°C to +85°C)	Z		0.015	0.035	°/s	4
	Y		0.05	0.18		
	X		0.03	0.08		
Accelerometer sensitivity	All three axis		0.1		°/s/g	

Note1: Measured as the average of 10 rotations in both directions on a rate table. Values may change after soldering; actual results prevail.

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

Note3: See Section 7.8 (Allan variance curves).Section 7.8 – Allan variance curves

Note4: Measured using lab temperature chamber + rate table with a temperature ramp < 3°C/min. See Figure 15 for detailed temperature-compensation curves.

7. 5 Accelerometer

Table 8: Accelerometer specifications

Parameters	Condition	Min	Nom	Max	Unit	Note
Full-scale range			12		g	
Resolution			16bit			
Initial bias				20	mg	1
Non-linearity			0.5		%Fs	
3 dB bandwidth			145		Hz	
Sampling rate			1600		Hz	
Bias instability	Allan Variance		0.03		mg	2
Bias stability	10 s smoothing		0.07		mg	
Bias repeatability	Allan Variance		0.3		mg	2
Random walk	Allan Variance		0.08		m/s/√h	2
Bias variation over temperature	-40 to 85℃		1	2.5	mg	3

Note1: Values may change after soldering; actual results prevail. See Section 7.7 (Initial bias).
Note2: See Section 7.8 (Allan variance curves).Section 7.8 – Allan variance curves
Note3: Measured using lab temperature chamber + rate table with a temperature ramp < 3℃/min. See Figure 15 for detailed temperature-compensation curves.

7. 6 Magnetometer

Table 9: Magnetometer specifications

Parameters	Condition	Min	Nom	Max	Unit	Note
Full-scale range			20		Gauss	
Sampling rate			200Hz			
Linearity			0.1		Fs%	

7. 7 Temperature sensor

Table 10: Temperature sensor specifications

Parameters	Condition	Min	Nom	Max	Unit	Note
Full-scale range		-104	-	150	℃	
Offset error			±1		K	

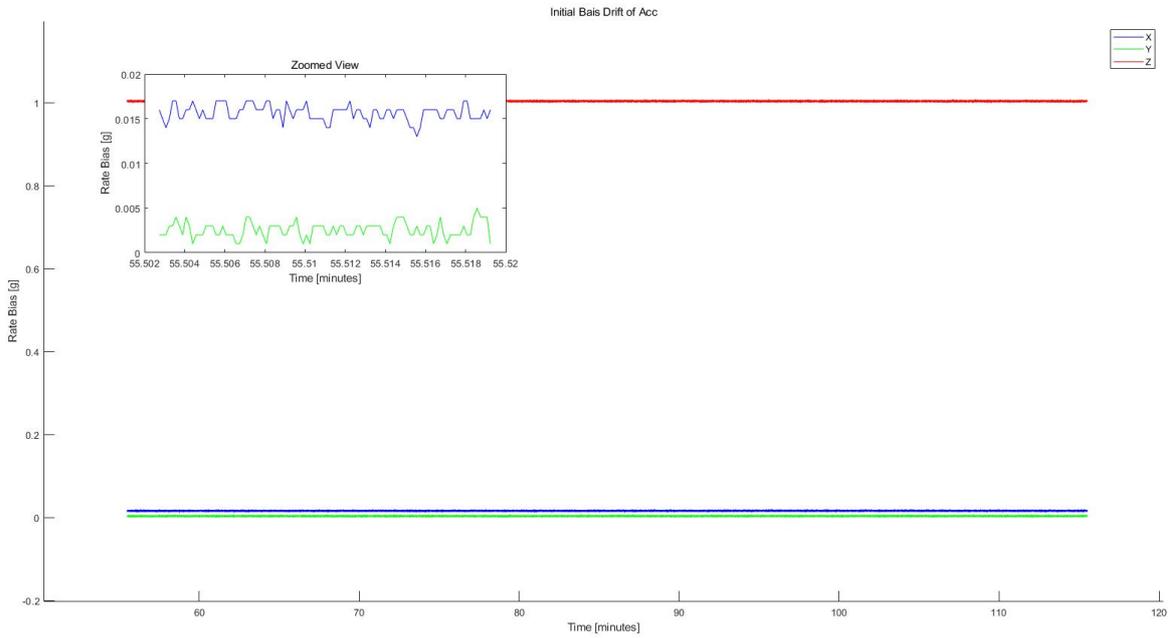## 7. 8 **Initial bias**

7. 8. 1 **HI04MX**

Figure3: HI04MX initial bias drift of accelerometer
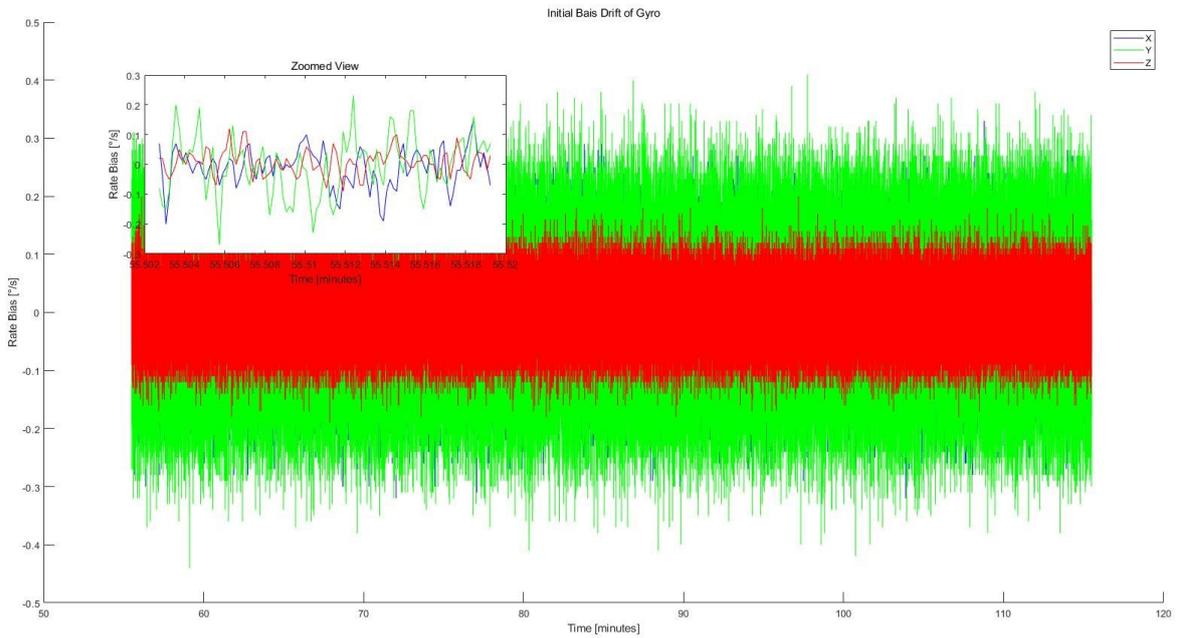
Figure4: HI04MX initial bias drift of gyroscope

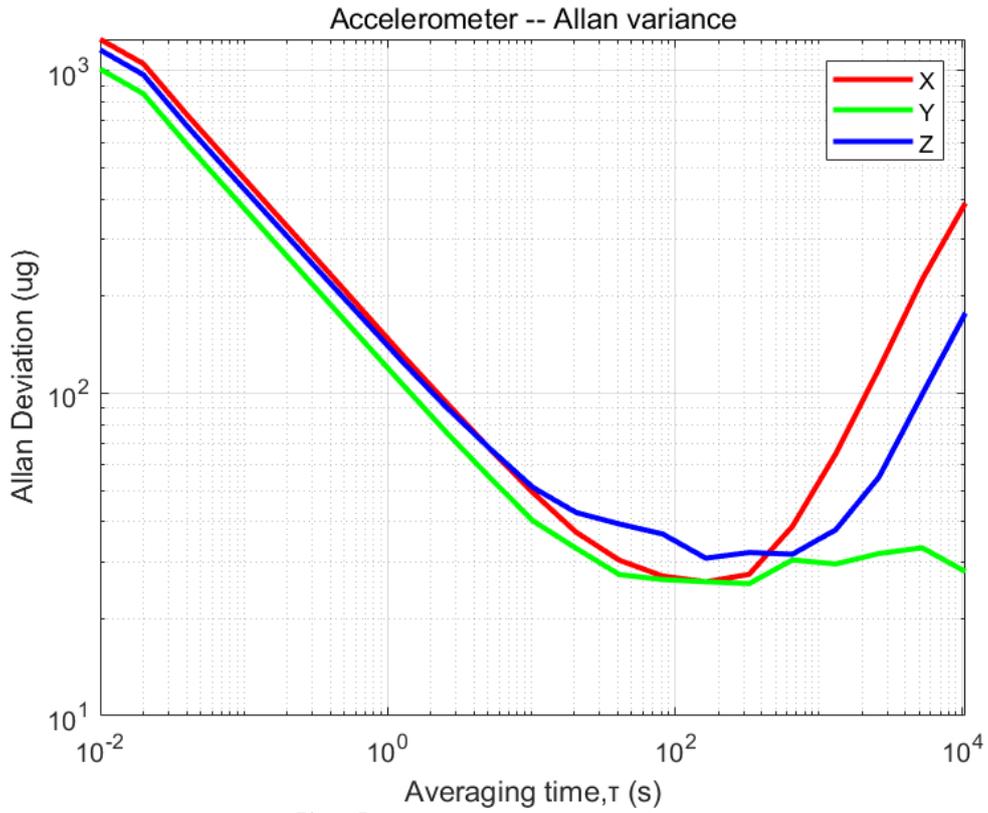## 7.9 **Allan variance curves**

7.9.1 **HI04MX**

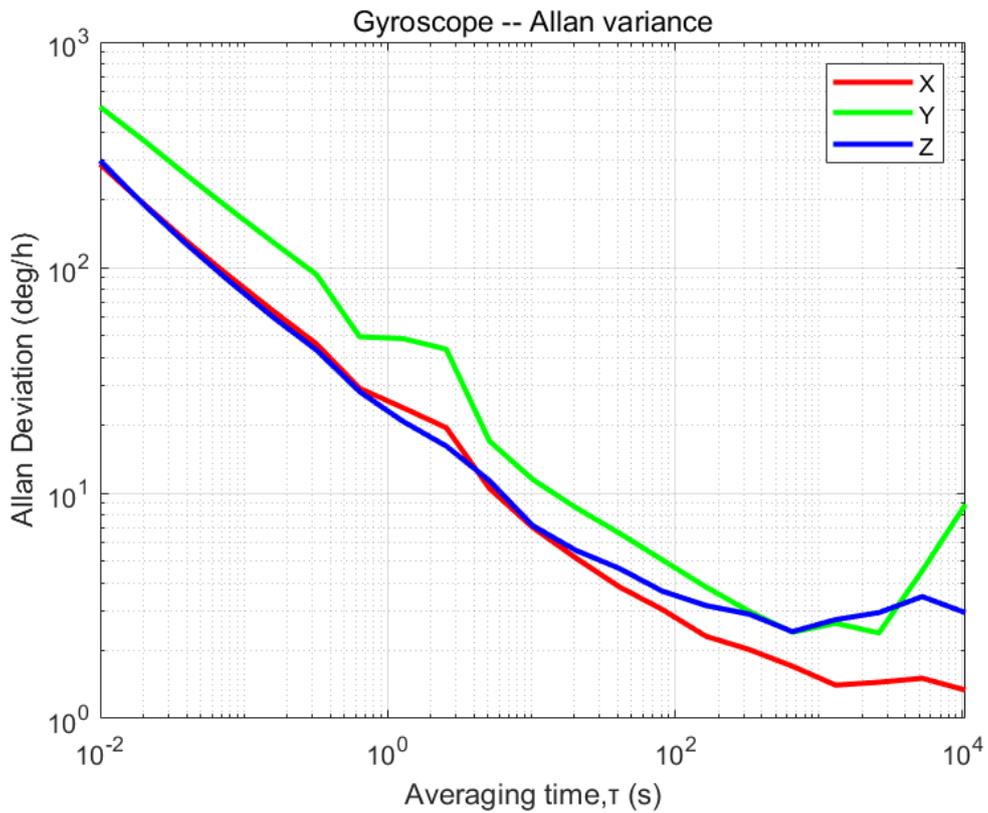**Figure5: HI04MX Accelerometer Allan Variance**

Figure6: HI04MX Gyroscope Allan Variance

7.10 **Gyroscope and accelerometer temperature characteristics**

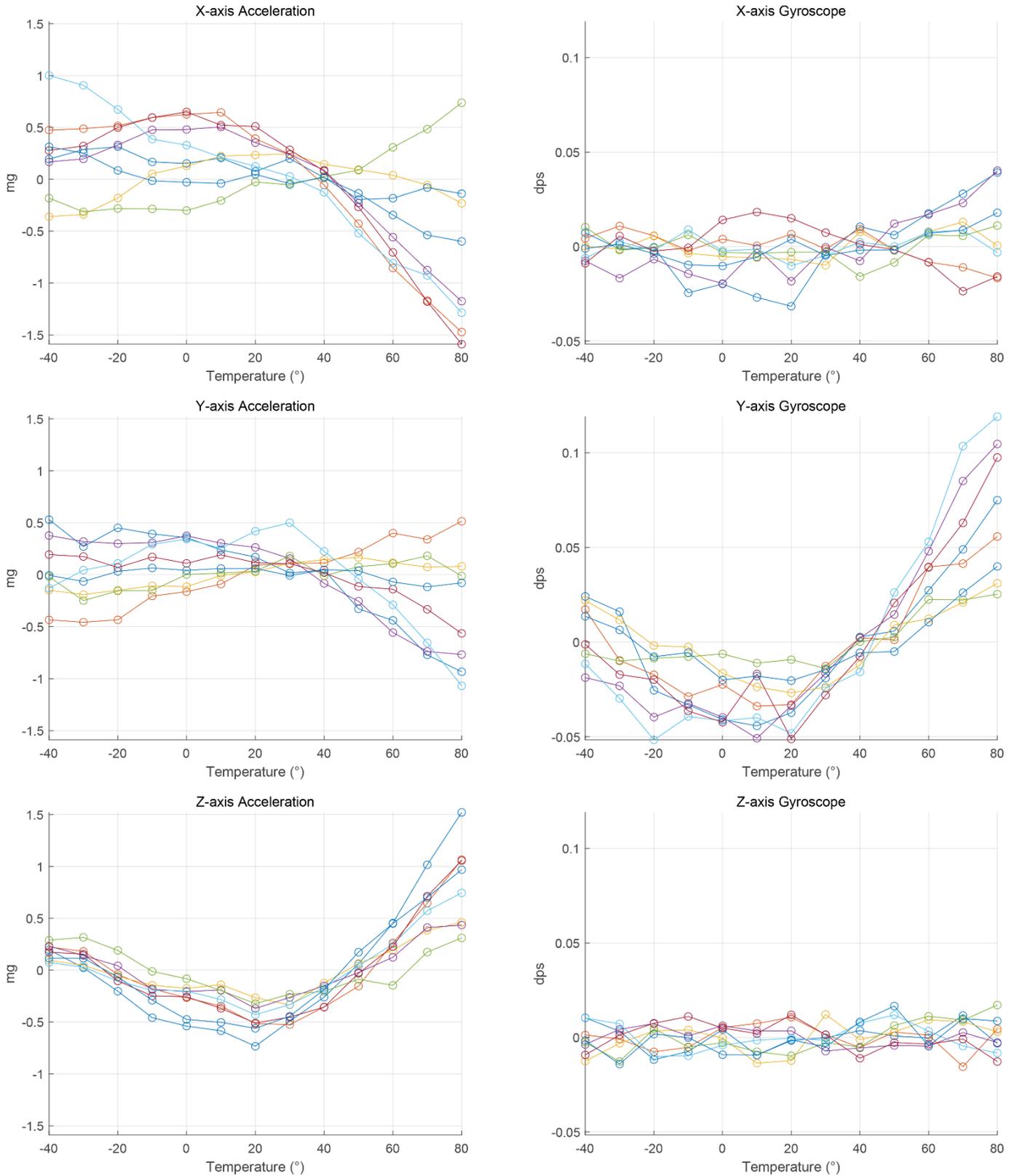The device under test is ramped from -40°C to +85°C and its bias is compensated; results are shown below.

Figure7: Accelerometer and Gyroscope Temperature Compensated Curve

7.11 **Fusion parameters**

Table 11: **Fusion parameters**

Parameters	Value
Pitch	±90°
Roll	±180°
Yaw (heading)	±180°
Resolution	0.01°

7.12 **Attitude accuracy**

Table 12: **Attitude accuracy**

Parameters	Condition	Product	Min	Nom	Max	Unit	Note
Pitch/Roll (static)				0.15	0.2	°	
Pitch/Roll (dynamic)				0.15	0.2	°	
Yaw static drift (6DOF)	Stationary for 2 h			0.15	0.2	°	1
Yaw dynamic drift (6DOF)		HI04M0		9		°	2
Yaw dynamic drift (AHRS)		HI04M3		2	3	°	3
Yaw rotation error (6DOF)	Rotation at 100°/s	HI04M0		<0.8	3	°	4

Note1: Module level and stationary for 2 hours
Note2: Measured on an indoor cleaning robot for 1 hour (1σ).
Note3: Measured after geomagnetic calibration with no surrounding magnetic interference; the product must be set to AHRS mode.
Note4: Cumulative heading error after 10 continuous rotations on a rate table

7.13 **Mechanical and environmental specifications**

Table 13: **Mechanical and environmental specifications**

Parameters	Value	Note
Dimensions	12.1X12.1X2.5mm	
Weight	<2g	
Shield material	Nickel silver (copper alloy)	
Vibration	1.0mm(10Hz-58Hz)&≤20g(58Hz-600Hz)	
Environmental compliance	RoHS Directive 2011/65/EU	
EMC	LVD Directive 2014/35/EU	
Drop test	Free drop 3 times from a 75 cm high workbench	
Thermal shock	Temperature ramp from -40°C to +85°C within 1 hour, 5 cycles	

7.14 **Package dimensions and pin definitions**
 All Dimensions in mm units.

7.14.1 **HI04MX package dimensions**

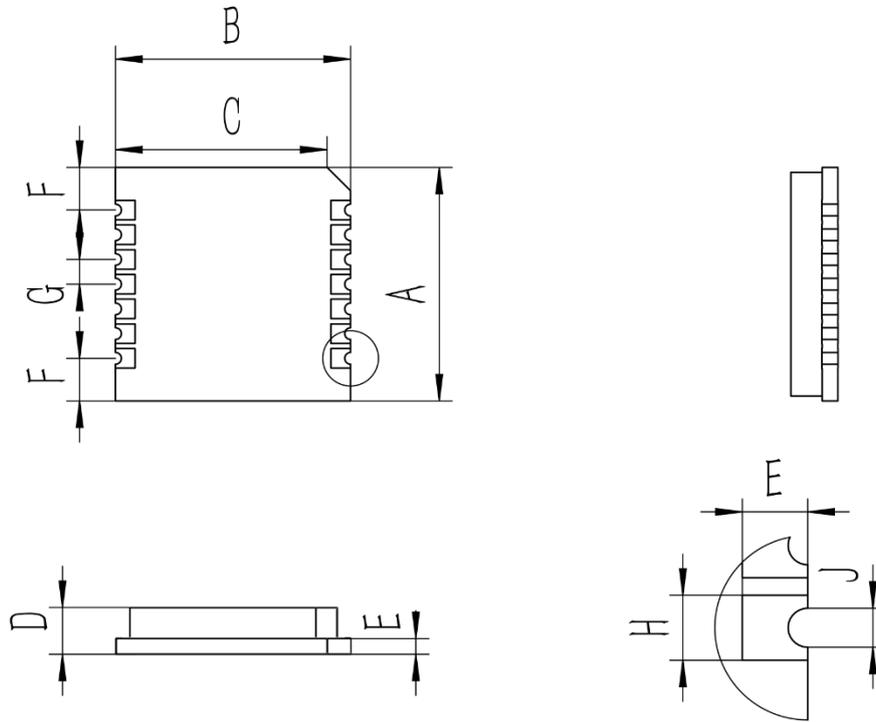Figure8: HI04MX mechanical specifications

7.14.2 **HI04MX dimension table**

Table 14: **HI04MX dimension table**

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	11.9	12.1	12.3
B	11.9	12.1	12.3
C	10.6	10.7	10.9
D	2.5	2.6	2.7
E	0.9	1	1.1
F	2.04	2.24	2.44
G	1.17	1.27	1.37
H	0.86	0.96	1.06
J	0.5	0.6	0.7

7. 14. 3 HI04MX recommended PCB footprint
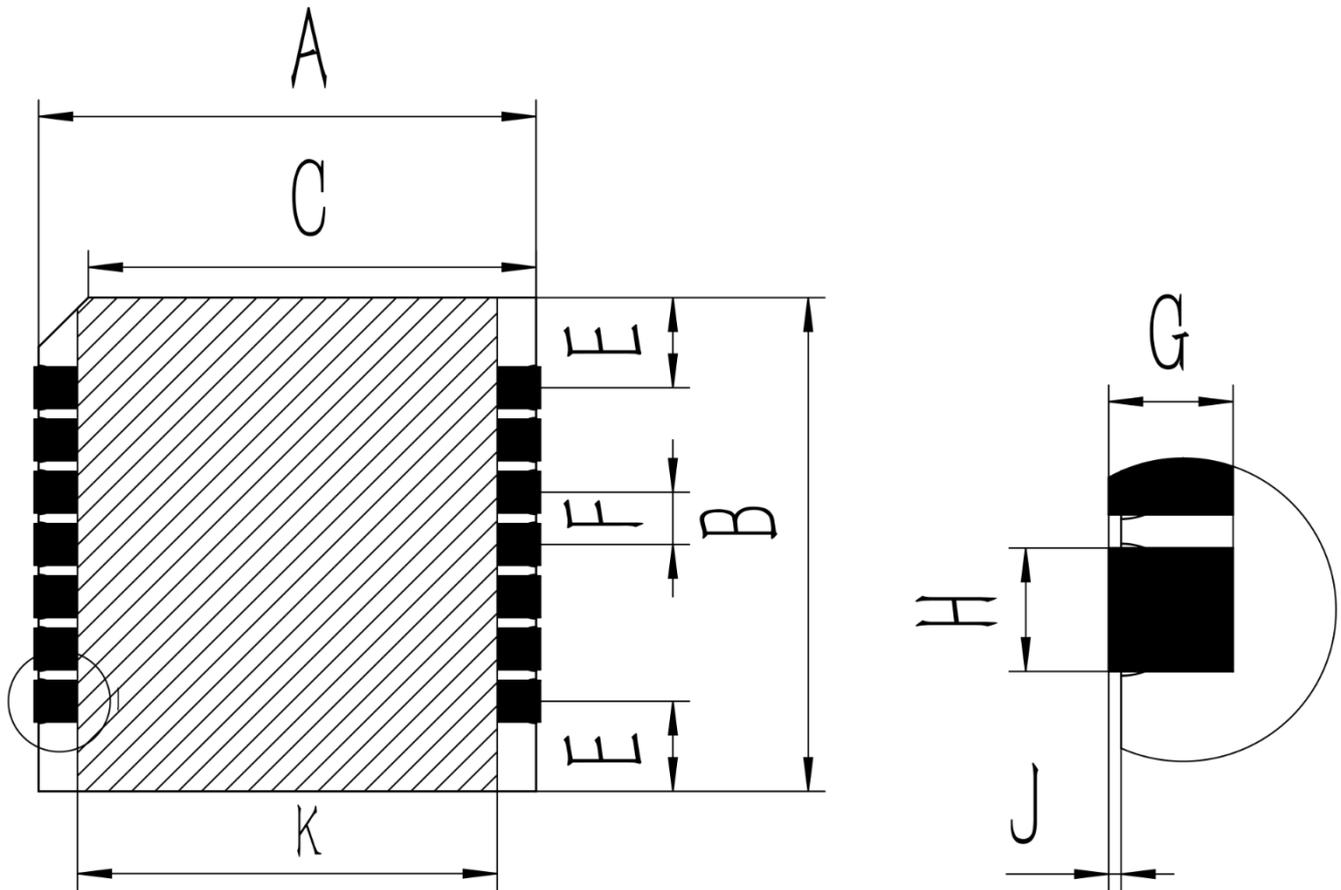

Figure9: HI04MX recommended PCB footprint

Note1: No copper pour or routing is allowed in the shaded area.

7. 14. 4 HI04MX recommended footprint dimension table

Symbol	Min(mm)	Typ(mm)	Max(mm)
A		12.1	
B		12.1	
C		10.7	
E		2.24	
F		1.27	
G		1.2	
H		0.9	
J		0.4	
K		9.9	

7. 14. 5 HI04MX pin assignment
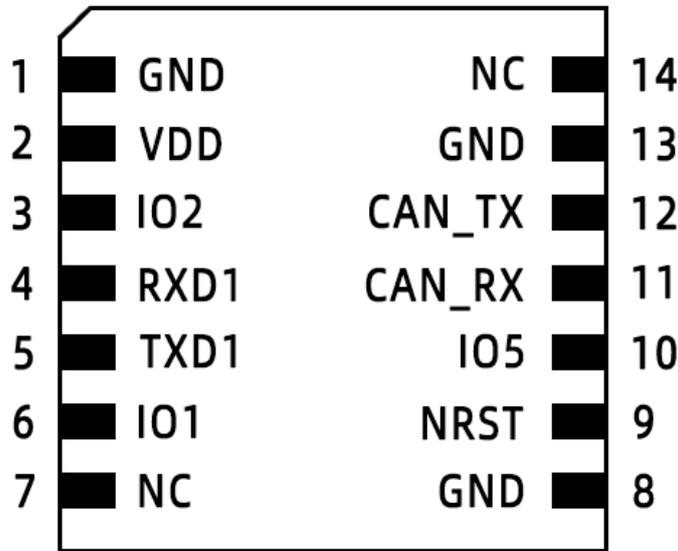
Figure10: HI04MX pin assignment

Table 15: Pin function description

Pin Number	Pin Name	Type	Functional		Note
1,8,13	GND	POWER	GND		
2	VDD	POWER	Power input 3.3 to 5 V		
3,6,10	IO2,IO1,IO5	I/O	PMUX1	SYNC_IN	Sync input; leave unconnected if unused
			PMUX2	SYNC_OT	Sync output; leave unconnected if unused
			PMUX3	LED	LED run indicator; leave unconnected if unused
			PMUX4	SOUT DIV	Sync output divider; leave unconnected if unused
			PMUX5	ALARM	Alarm signal output; leave unconnected if unused
4	RXD1	I	Module UART1 RX		
5	TXD1	O	Module UART1 TX		
7,14	NC	-	Leave unconnected		
9	NRST	I	Reset pin (active low). No external RC network required. Recommended to connect to a host GPIO; may also be left unconnected.		
11	CAN_RX	I	Module CAN RX		
12	CAN_TX	O	Module CAN TX		

8 Coordinate system definition

8.1 Coordinate system

The body frame uses a Right-Forward-Up (RFU) coordinate system, and the navigation frame uses East-North-Up (ENU). Accelerometer and gyroscope axes are shown below:
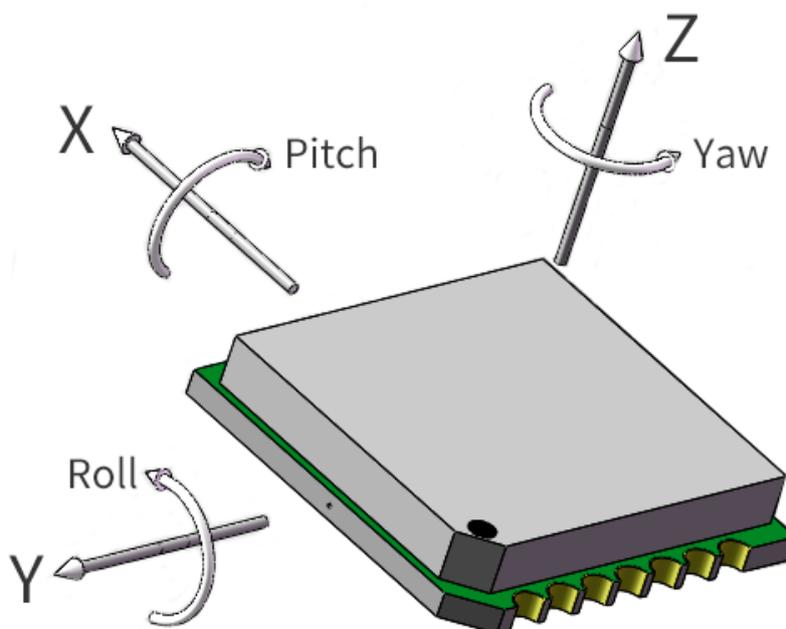
Figure11: HI04 Coordinate System

The Euler angle rotation order is ENU-312 (rotate about Z, then X, and finally Y). Definitions are as follows:
Rotation about the Z axis: Yaw angle ψ, range: −180° to +180°
Rotation about the X axis: Pitch angle θ, range: −90° to +90°
Rotation about the Y axis: Roll angle φ, range: −180° to +180°

If the module is treated as an aircraft, the positive Y axis points toward the nose. When the sensor frame coincides with the inertial frame, the ideal Euler outputs are: Pitch = 0°, Roll = 0°, Yaw = 0°.

To change the default coordinate system, refer to the Command and Programming Manual.

8.2 Sensor center-of-mass (reference) location

Table 16: HI04 series sensor center location

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

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9 Typical reference design

9.1 Power supply

The HI04 series integrates an on-board LDO, power filtering, and over-current/over-voltage protection to minimize interference from external supply noise. The module can be powered by an LDO or DC-DC supply within 3.3–5 V.
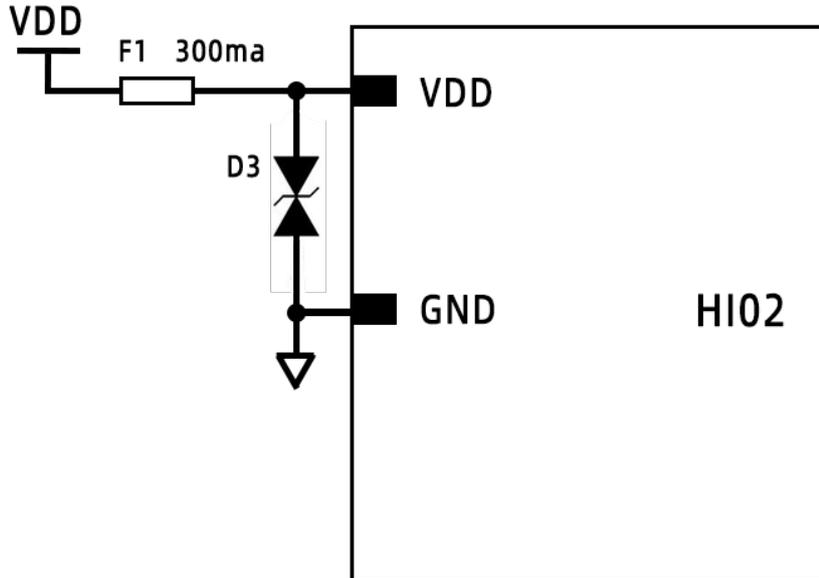
9.2 UART communication

A 3.3 V logic level is recommended for the host processor. If UART communication with 5 V or 1.8 V logic is required, the user should add a level shifter. We recommend 74LVCH1T45GW,125 provided it does not impact the UART baud rate.
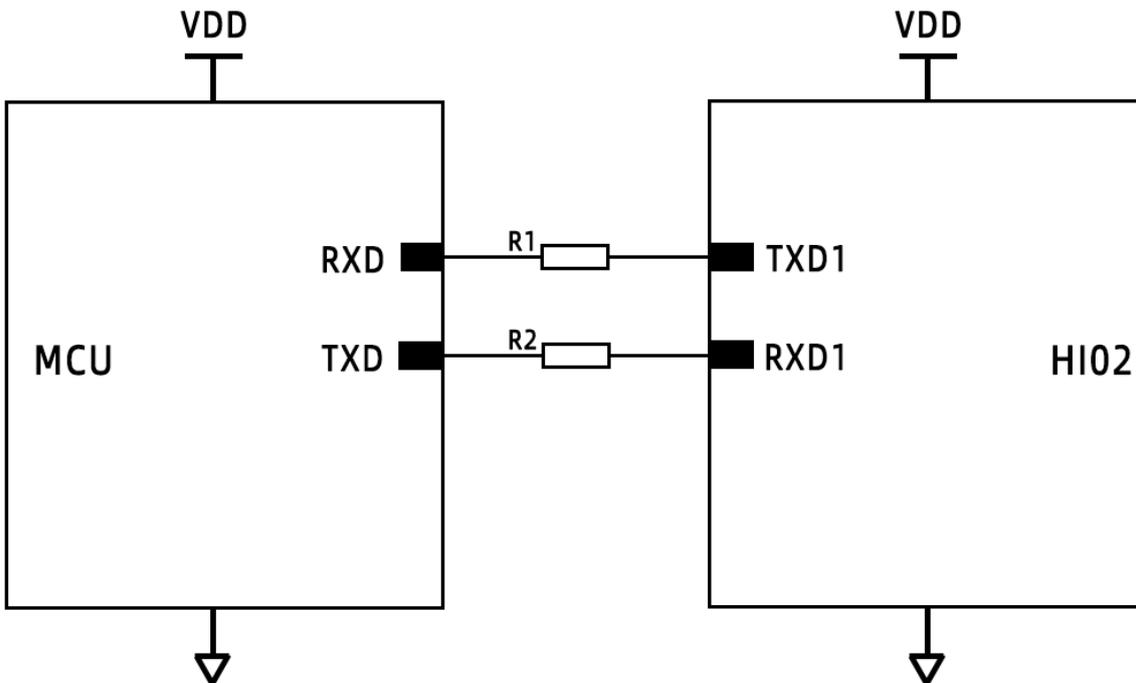
9.2.1 Minimal UART system reference design

Figure12: HI04 UART reference schematic

9.2.2 UART communication (IMU synchronized with host)

This connection requires wiring SYNC_IN/SYNC_OUT to the host system for data synchronization. They may be used independently; selection depends on the system design.
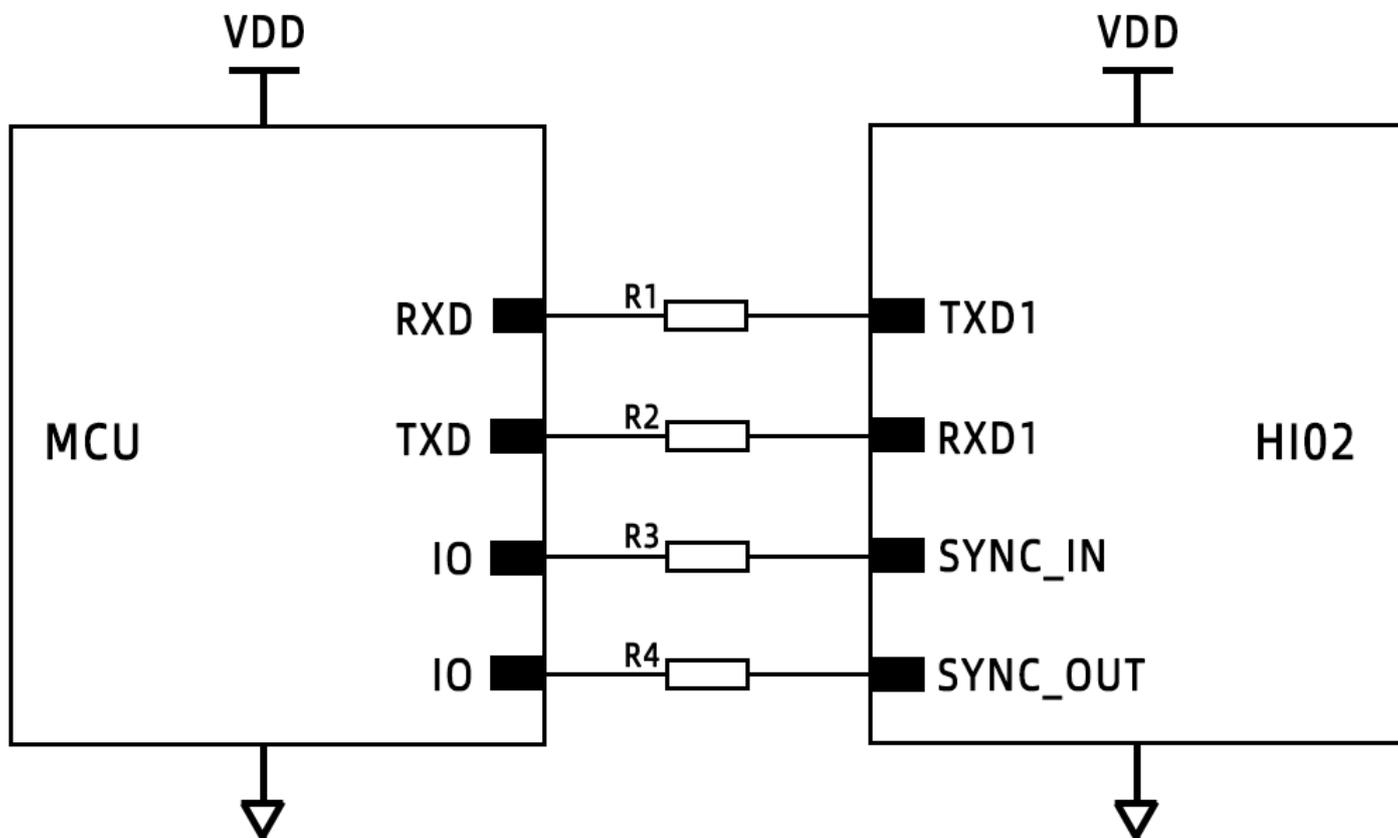
Figure13: HI04 UART without synchronization

Note1: If SYNC_IN is used, the MCU pulse frequency should match the output data rate; see the Programming Manual for details.

Note2: If SYNC_OUT is used, it can serve as a Data Ready signal; see the Programming Manual for details.

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9.2.3 UART communication (IMU synchronized with external systems)

The HI04 series supports synchronization with external systems (camera/LiDAR). Ensure that the IMU and the external system share a common ground.

Connection method 1: The IMU connects to both the host and the external sync device.

Figure14: HI04 UART with external system synchronization 1

Note1: If IO2 is used, set IO2 to Sync Output (PMUX2). The MCU will receive pulses at the output data rate and IO2 can be used as a Data Ready signal; see the Sync Function section and Programming Manual for details.

Note2: If IO1 is used, set IO1 to Sync Input (PMUX1). The MCU pulse frequency should match the output data rate. GNSS PPS may also be used to synchronize the product; see the Programming Manual for details.

Note3: If IO6 is used, set IO6 to SYNC_OUT_DIV to trigger camera/LiDAR devices. Ensure the IO6 sync frequency is within the acceptable range of the external system.

Connection method 2: The IMU connects only to the external sync device.

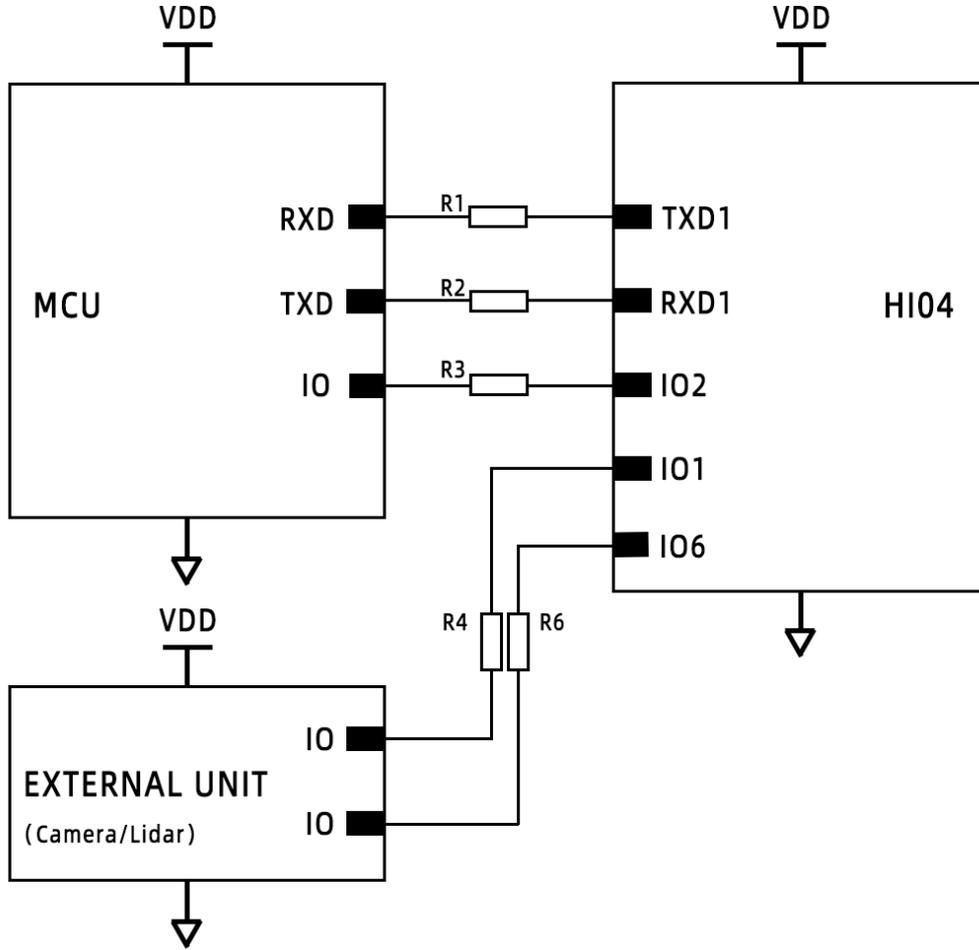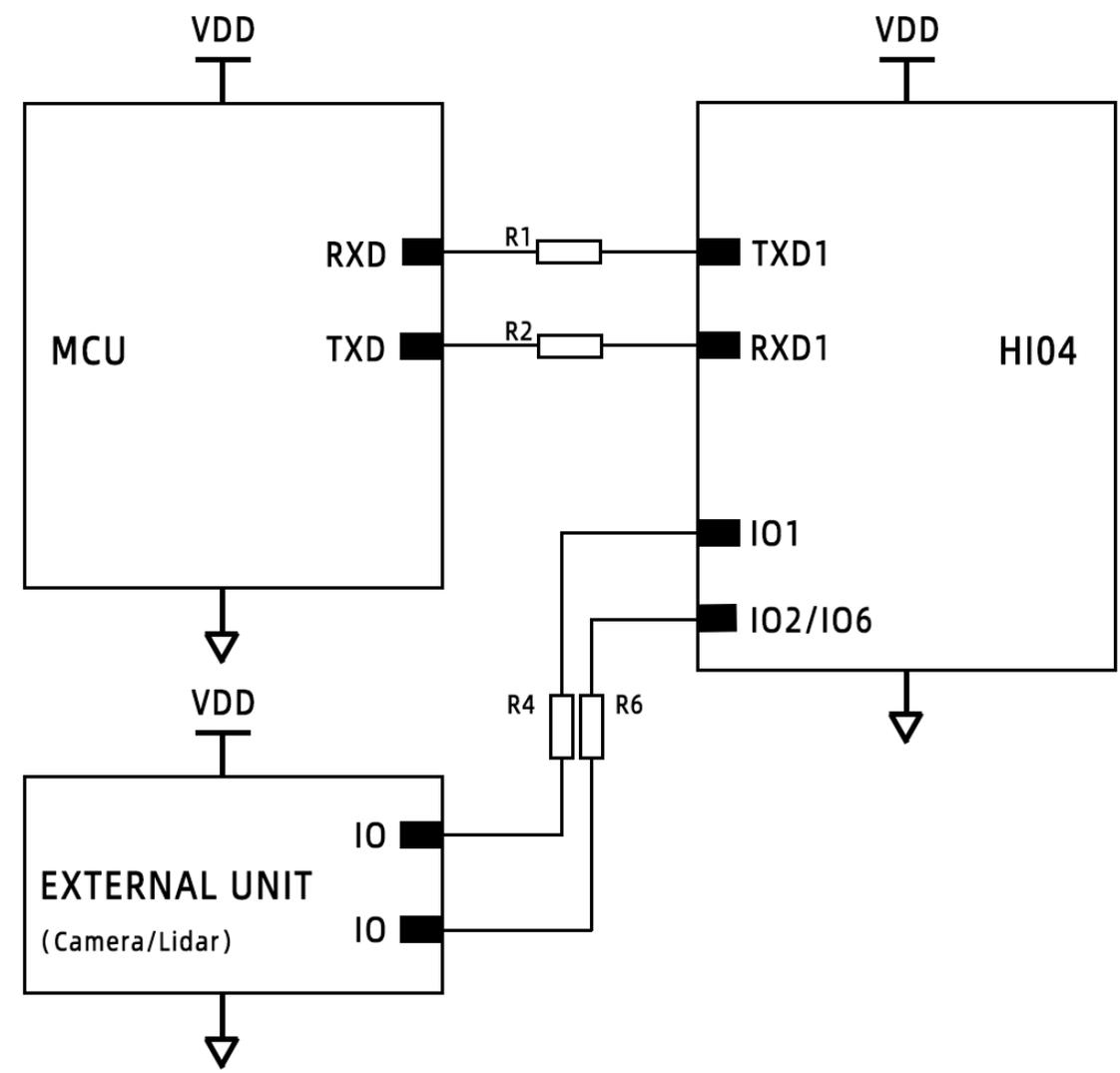**Figure15: HI04 UART with external system synchronization 2**

Note1: If IO1 is used, set IO1 to Sync Input (PMUX1). The MCU pulse frequency should match the output data rate. GNSS PPS may also be used to synchronize the product; see the Programming Manual for details.

Note2: If IO2/IO6 are used, configure IO2/IO6 as sync outputs (PMUX1/PMUX4) to trigger camera/LiDAR devices. Ensure the sync frequency is within the acceptable range of the external system.

9.3 CAN communication

9.3.1 HI04MX CAN reference circuit

Figure16: HI04M0 CAN communication reference circuit

Note1: R6 and R7 are CAN bus termination resistors (60.4 Ω). The user may populate them as needed for the application.

Table 17: Reference design BOM

Item	Reference	Part	P/N	Vendor
Fuse	F1	300mA	JK-SMD0603-030-6	JK
TVS	D3	SMF5.0CA	SMF5.0CA	TWGMC
Resistor	R1,R2,R3,R4,R6	1K	RC0402JR-071KL	YAGEO
Resistor	R7,R8	60.4Ω	RC1206FR-0760R4L	YAGEO
Capacitor	C1,C2	0.1uF	CC0402KRX5R7BB104	YAGEO
Capacitor	C3,C4	100pF	CC0402JRNPO9BN101	YAGEO
Capacitor	C5	1nF	CC0402KRX7R9BB102	YAGEO
Common Choke	T1	5.8kΩ@10MHz 100uH@100kHz 150mA	ACT45B-101-2P-TL003	TDK
TVS	D1,D2	SMBJ15CA	SMBJ15CA	BORN

10 Initial configuration

The HI04 series is designed to require minimal configuration to cover most application scenarios. The default settings satisfy many use cases, while additional options are provided for special scenarios.

10.1 Interface default configuration

Table 18: Interface default configuration

Interf	Parameters	Value	Unit	Note
UART	Baud rate	115200	bps	2
	Start bit	1	bit	
	Data length	8	bits	
	Stop bit	1	bit	
	Parity	None		1
	Protocol	Binary protocol (0x91)		
	Output data rate	100	Hz	3
CAN	Protocol	CANopen		1
	Baud rate	500K	bps	2
	Output data rate	100	Hz	3

Note1: To change the protocol, refer to the Command and Programming Manual.To change the protocol, refer to the Command and Programming Manual.

Note2: To change the baud rate, refer to the Command and Programming Manual.To change the baud rate, refer to the Command and Programming Manual.

Note3: To change the output rate, refer to the Command and Programming Manual.To change the output rate, refer to the Command and Programming Manual.

10.2 Sensor default configuration

Table 19: Sensor default configuration

Parameters	Value	Unit	Note
Gyroscope full-scale range	±2000	°/s	1
3 dB bandwidth	47	Hz	1
Accelerometer full-scale range	±12	g	1
3 dB bandwidth	145	Hz	1
Magnetometer full-scale range	±8	Gauss	1
Mode	6DOF		1

Note1: To change range, bandwidth, mode, and other parameters, refer to the Command and Programming Manual.To change range, bandwidth, mode, and other parameters, refer to the Command and Programming Manual.

11 Communication protocols

11.1 Serial binary protocol

For ease of use, we provide a rich set of serial protocols. For details, refer to the Command and Programming Manual.

11.2 CAN

11.2.1 CANopen

The CAN interface complies with CANopen. All communications use standard data frames. For details, refer to the Command and Programming Manual.Command and programming manual

11.2.2 J1939

The module outputs CANopen by default. For SAE J1939 support, please contact us.

12 Synchronization

If a system includes multiple subsystems such as LiDAR, cameras, and GNSS, data synchronization becomes critical. Our IMU supports sync pulse input and sync output for convenient integration.

Note1: The IMU and external sync system must share a common ground. For usage details, refer to the Command and Programming Manual.

13 Soldering and installation
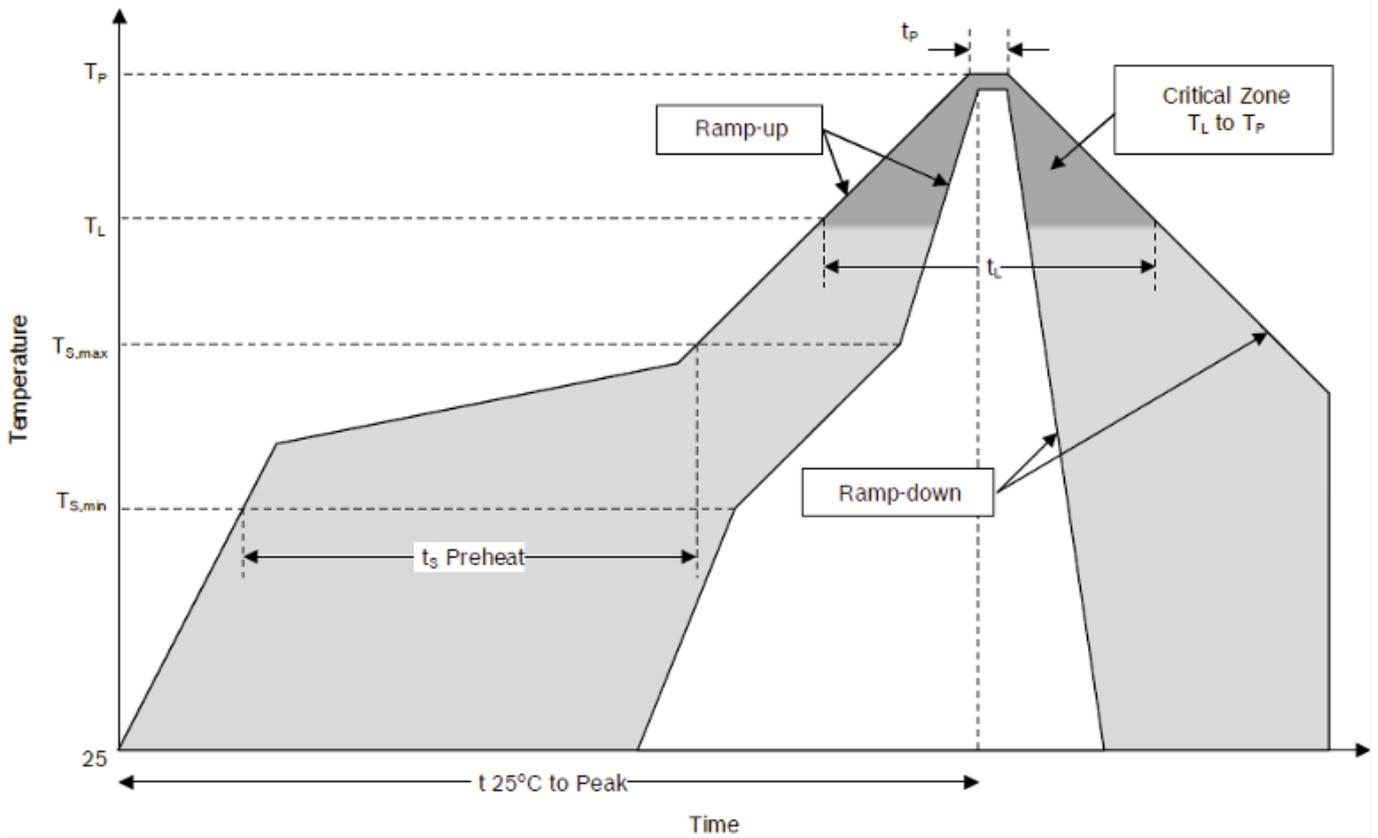
13. 1 **Reflow profile**

Figure17: SMT temperature profile

Table 20: **Reflow profile description**

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

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13. 2 **Installation recommendations**

In general, MEMS sensors are high-precision measurement devices combining electronic and mechanical structures. When mounting the sensor on a printed circuit board (PCB), consider the following recommendations to achieve accuracy, efficiency, and mechanical robustness:

- It is recommended to mount the module level on the measured platform.
- Do not place the sensor directly under or next to button contacts, as this can introduce mechanical stress.
- Do not place the sensor near high-temperature hot spots (e.g., controllers or graphics chips), as this can heat the PCB and the sensor. Also avoid areas of maximum mechanical stress (e.g., the center of a diagonally-crossed PCB), which can bend the PCB and the sensor.
- Do not mount the sensor too close to screw holes. Avoid regions of the PCB where resonance (vibration) may occur or is expected.

If the above recommendations cannot be properly implemented, performing a specific in-system offset calibration after placing the device on the PCB may help minimize potential impacts.
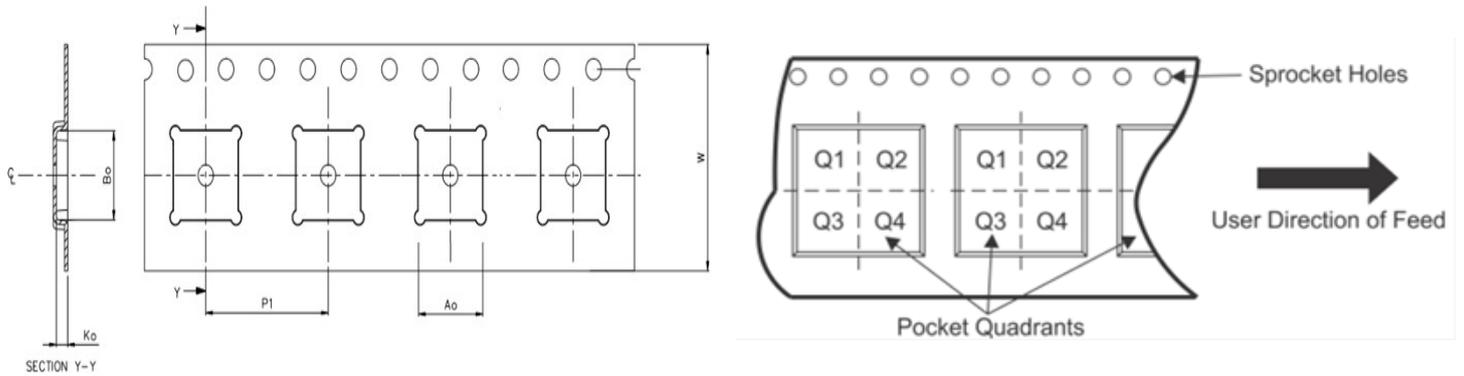
14 Packaging

14.1 Tape Dimension

Figure18: Tape Dimension and pin 1

Table 21: Tape Dimension Information

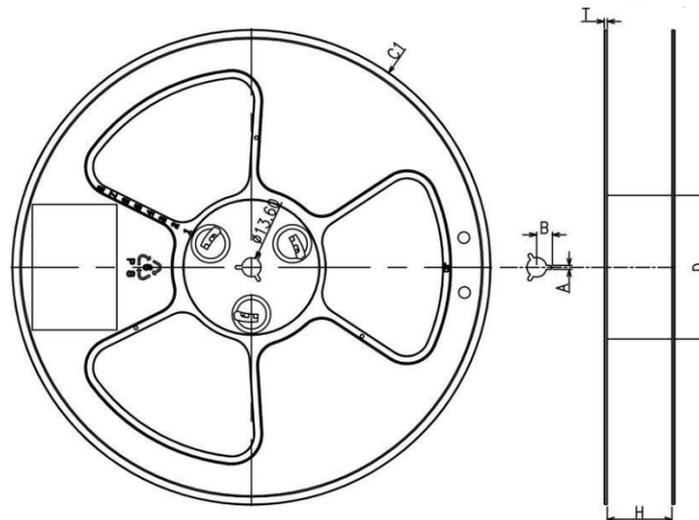| Device	A0(mm)	B0(mm)	K0(mm)	P1(mm)	W(mm)
HI04M0/M3	12.5	12.5	3.0	16	24

14.2 Reel Dimension

Figure19: Reel Dimension

Table 22: Reel Dimension Information

Device	SPQ(PCS)	Reel Diameter C1(mm)	Reel Width H(mm)	A(mm)	B(mm)	T(mm)	D(mm)
HI04M0/M3	1000	330	12.8	2.5	11	2.0	100

14.3 Packing method

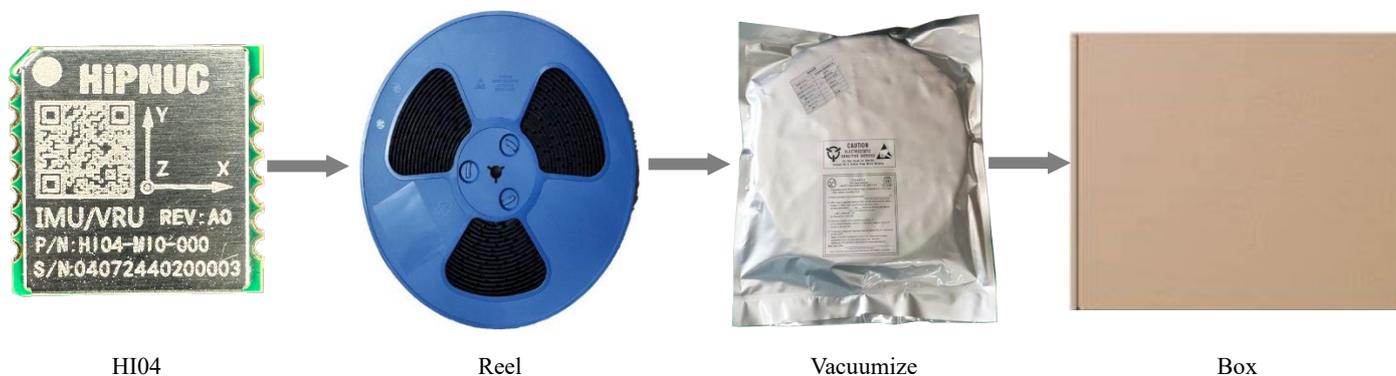The HI04 series uses standard carton packaging.

Table 23: Packing

| HI04 | Reel | Vacuumize | Box |

Table 24: Carton dimensions

Device	SPQ(PCS)	L(mm)	W(mm)	H(mm)
HI04	1000	360	360	40

15 FAQ

15. 1 UART issues

There are many reasons why the IMU cannot be configured or its data cannot be received correctly. Typical cases include:

1. The IMU UART is not cross-connected to the host UART (TX↔RX). Symptoms: the IMU cannot be configured and data cannot be received, as shown below:
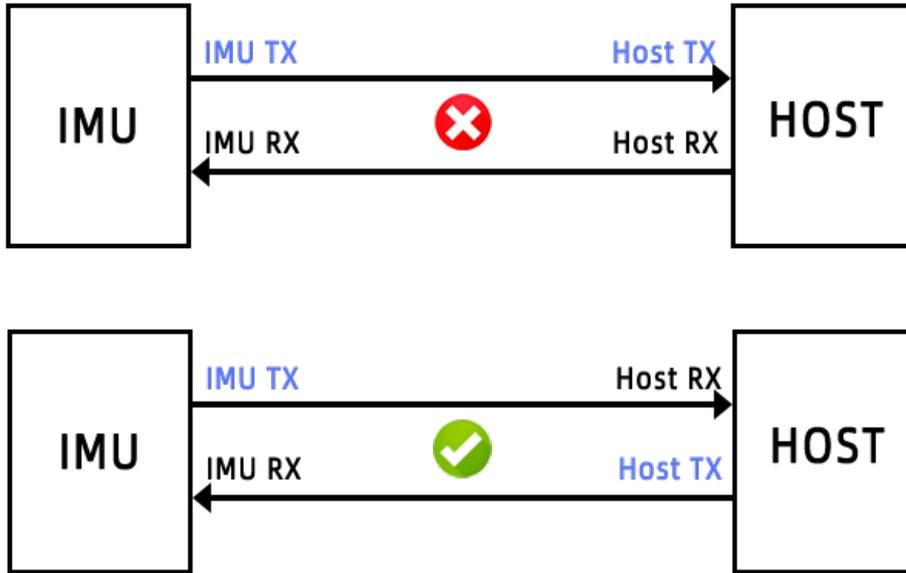

Figure20: IMU UART connected to a single host

2. Incorrect UART configuration

UART settings include baud rate, start bit, data length, parity, stop bit, etc. See Section 10.1 for defaults. The most common issue is a baud-rate mismatch—especially after changing the IMU baud rate without updating the host. Symptoms: the IMU cannot be configured and data cannot be received, as shown below:
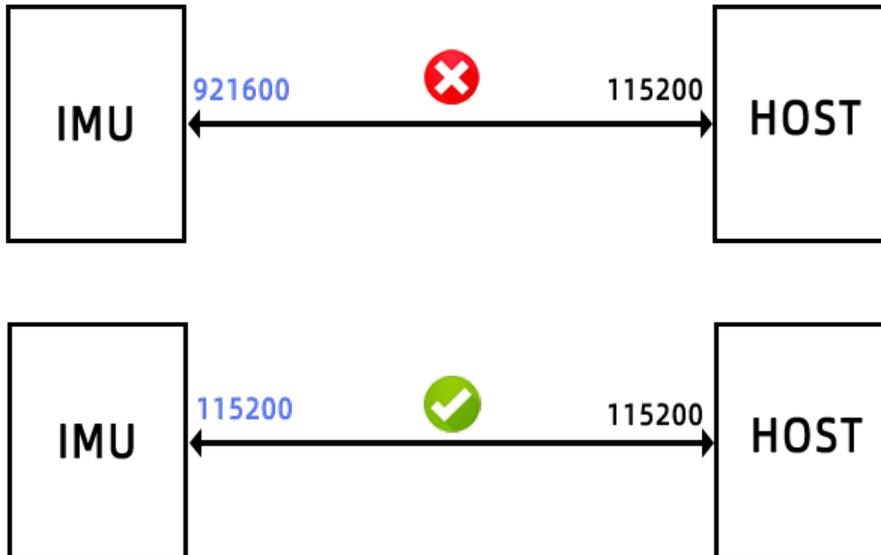

Figure21: IMU UART connected to a single host

Note2: The same baud-rate mismatch issue also applies to the CAN interface; the IMU and host must use the same CAN bit rate.

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3.   IMU RX connected to multiple devices' TX lines

Sometimes the UART is inadvertently connected to two host devices. In this case, both hosts may receive IMU data, but the IMU cannot be configured. A typical example is connecting the IMU to both the user host and our PC GUI at the same time (see Figure 27).
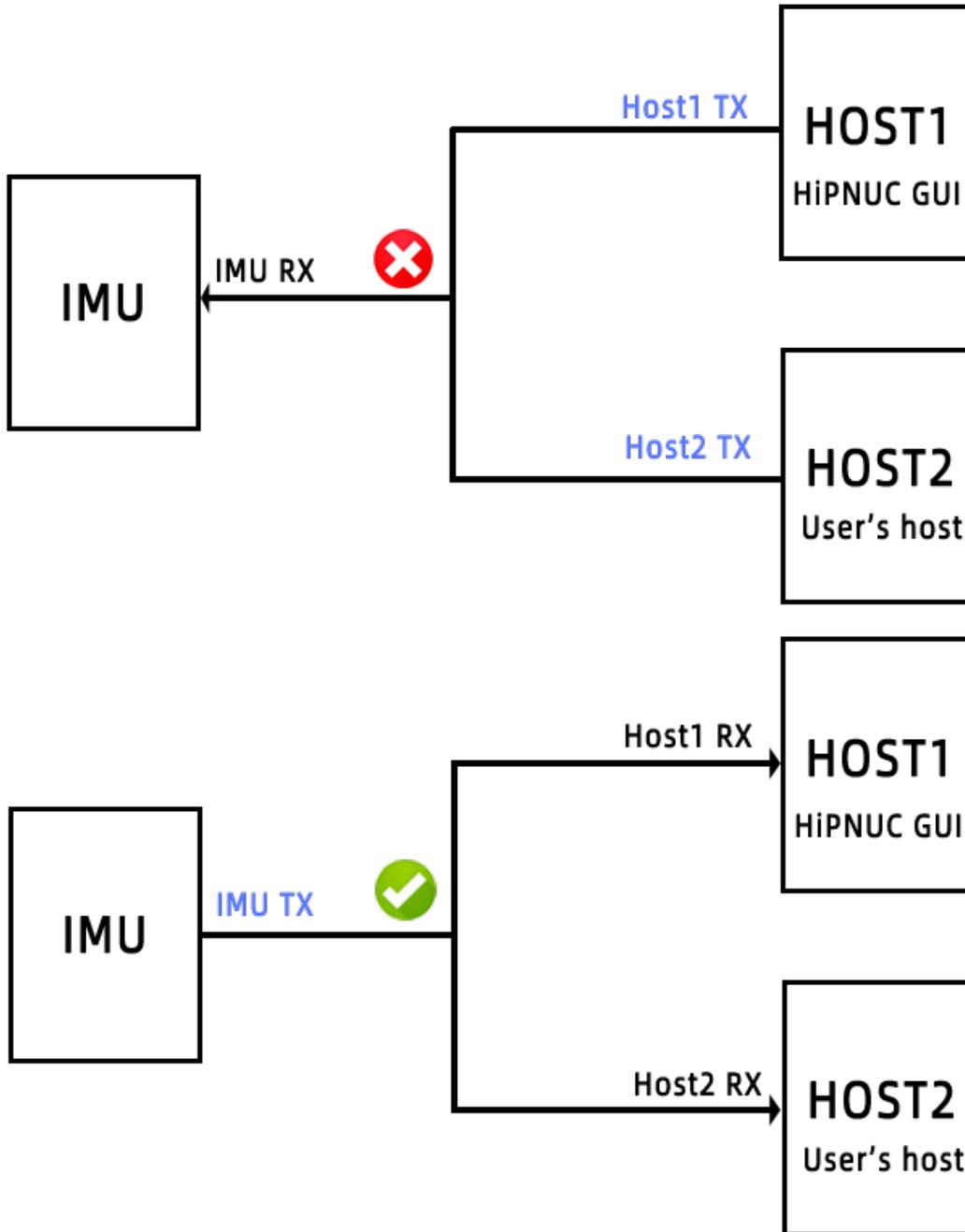

Figure22: IMU UART connected to both the user host and the GUI simultaneously

4.   Software issues

The host receiver software may be incomplete (e.g., incorrect parsing, CRC check failure), which can prevent correct data reception and configuration. In this case, refer to our official parsing examples or contact us for technical support.

5.   Other issues

Cold solder joints or poor connections, overly long cables, or low-quality harnesses can also cause issues. We recommend using the USB-to-UART cable provided by us, which is designed for full-scenario applications.