1 FEATURES

1.1 Hardware

- High-performance, low-noise MEMS IMU
- Factory full-temperature calibration from -40 to 85°C, calibrating scale factor, cross-axis, and bias
- Gyroscope Bias Instability as low as 1.7°/h
- Accelerometer Bias Instability as low as 0.012 mg
- Precise synchronization signals, supporting PPS and UTC time sync
- Excellent vibration resistance
- Integrated temperature sensor
- Compact size, easy to integrate
- RoHS and CE certified

1.2 Software

- Adaptive Extended Kalman fusion algorithm, output up to 1000 Hz (HI16RX), with low latency
- Excellent dynamic tracking performance with good vibration suppression
- Outstanding suppression of linear acceleration effects
- Start-up time < 1 s
- PPS+GPRMC/UTC synchronization(HI16RX)
- Supports multiple protocols such as binary and CANopen
- Outputs data directly without external configuration commands
- Rich set of user configuration commands
- Multifunctional GUI for easy operation
- Supports various sample projects for ROS, C, and Qt

2 APPLICATIONS

- Precision instruments and meters
- Platform stabilization and control
- Construction machinery
- Humanoid robots
- UAVs
- Low-speed autonomous robots

3 DESCRIPTION

3.1 Appearance

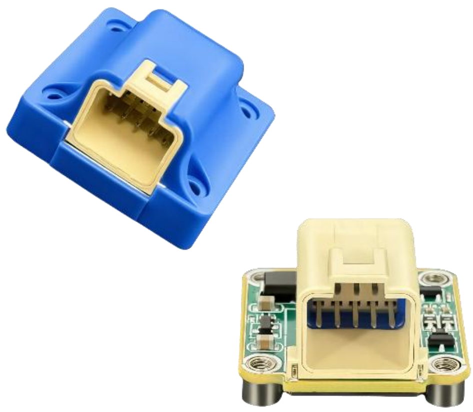

Figure1: HI16

3.2 System Block Diagram

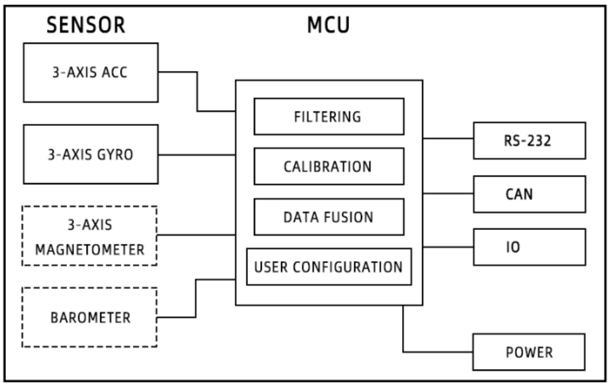

Figure2: Functional block diagram

Note1: Dashed boxes indicate features not supported by certain models; see the product selection table (Table 1) for details.

3.3 General Description

The HI16 series are IMU/VRU/AHRS sensors built around a MEMS IMU, featuring proprietary adaptive Extended Kalman filtering, dynamic IMU noise analysis algorithms, and carrier motion state analysis algorithms. They deliver high attitude-angle accuracy under high dynamics and reduce heading drift.

The HI16 series communicates via UART/CAN interfaces and offers extensive user configurability.

The multifunctional PC GUI facilitates rapid evaluation, including (but not limited to) module configuration, data display, firmware upgrade, and data logging. For model selection and ordering information, please refer to Table 1 and Table 2.

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4 PRODUCT SELECTION

Table 1: Model Information

HI16a-b-cde [1]								
Company	Series	a-Sensor		b-Interface		c- Synchronization	d-Shell	e-OEM
		M0	6DoF 3.0°/h 0.03mg	232	2XRS232	1 Supported	0 BOX	0 Default
HI	16	R2	6DoF 1.7°/h 0.012mg	URT	2XUART(TTL)		1 PCBA	Other OEM
				MI1	RS232+CAN			

Note1: Example: HI16R2-232-100

5 ORDERING

5.1 Ordering Information

Table 2: Ordering Information

Part Number	Name	Description	Note
HI16M0-232-100	IMU/VRU Module	6DoF 3°/h 0.03mg Sync Box 2XRS-232	
HI16M0-232-110	IMU/VRU Module	6DoF 3°/h 0.03mg Sync PCBA 2XRS-232	
HI16R2-URT-100	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync Box 2XUART(TTL)	
HI16R2-URT-110	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync PCBA 2XUART(TTL)	
HI16R2-232-100	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync Box 2XRS-232	
HI16R2-232-110	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync PCBA 2XRS-232	
HI16R2-MI1-100	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync BOX RS-232+CAN	
HI16R2-MI1-110	IMU/VRU Module	6DoF 1.7°/h 0.012mg Sync PCBA RS-232+CAN	

5.2 Contact Us

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

6 DOCUMENT

6.1 Scope

The document is applicable to modules with hardware version A0 and above

6.2 Document Version Information

Table 3: Document Version

Version	Date	Chapter	Changes
1.0	Jun 2, 2025	-	Initial Version

6.3 Related Documents

1. *Commands and Programming Manual*
2. *3D Step*
3. *CE/RoHS and other certification documents*
4. *GUI Host and Reference Examples*

7 SYSTEM ARCHITECTURE

The HI16 series is a fully functional sensor module integrating various functions such as IMU, VRU, and AHRS. It has undergone rigorous calibration tests for scale factors, cross-axis, temperature, and zero offset at the factory, providing users with fundamental sensor data (acceleration, angular velocity, geomagnetic field, air pressure), three-dimensional orientation data (Euler angles, namely pitch, roll, yaw), quaternion data, etc. If the user connects to an external GNSS, it can also provide information such as speed and position.

HI16 module is equipped with a 3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer, and a high-performance processor. This controller is primarily used for sensor synchronization, calibration, algorithm fusion, and user configuration, etc. Additionally, based on application scenarios and sensor characteristics, we provide users with various modes such as 6DOF, AHRS, magnetometer-assisted heading angle, humanoid robots, high vibration, etc. For details, refer to the instructions and programming manual.

7.1 IMU Subsystem

The HI16 can serve as an IMU, providing users with three-dimensional acceleration and angular velocity. Compared to traditional IMU chips, its advantages lie in the fact that these data have undergone our factory's stringent calibration and compensation, including (cross-axis, scale factor, zero offset, temperature).

7.2 VRU Subsystem

Through our self-developed algorithm fusion engine, the HI16 can output three-dimensional orientation data based on a gravity reference frame using IMU foundational data. This data includes drift-free pitch angle, roll angle, and unreferenced yaw angle (starting from 0 degrees upon power-up), possessing excellent anti-vibration and dynamic properties. Although the yaw angle is unreferenced, it still features industry-leading low-drift characteristics.

7.3 AHRS Subsystem

Building on the IMU/VRU foundation, we have introduced a high-precision, large-range TMR geomagnetic sensor, upgrading the HI16 to a more powerful attitude reference system, AHRS, which can output drift-free pitch angle, roll angle, and magnetic north-based yaw angle for users.

8 PIN DEFINITIONS

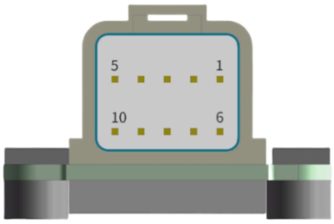


Figure3: HI16 pin assignment

8.2 UART Interface

Table 4: UART Pin Functional Description

Pin Number	Pin Name	Type	Functional	Note
1	RXD1	I	UART1 RX (Module)	1
2	RXD2	I	UART2 RX (Module)	1
3	SGND	Power	Signal GND	2
4	IO2(SYNC_OUT)	I/O	Sync Output, can be used as a Data Ready signal	
5	GND	Power	Power GND	2
6	TXD1	O	UART1 TX (Module)	1
7	TXD2	O	UART2 TX (Module)	1
8	SGND	Power	Signal GND	2
9	IO1(SYNC_IN/PPS)	I/O	Sync Input, accepts external trigger signals (e.g., GNSS PPS)	
10	Vs	Power	Power Input 5-30 V	

Note1: The UART voltage levels depend on the specific product model purchased by the user.

Note2: Power ground (PGND) and signal ground (SGND) are internally connected.

8.3 MI1 Interface

Table 5: MI1 Pin Functional Description

Pin Number	Pin Name	Type	Functional	Note
1	RS232_RX1	I	Module COM1 RX, RS-232 level	
2	CAN H	AIO	CAN High	
3	SGND	Power	Signal GND	1
4	IO2(SYNC_OUT)	I/O	Sync Output, can be used as a Data Ready signal	
5	GND	Power	Power GND	1
6	RS232_TX1	O	Module COM1 TX, RS-232 level	
7	CAN L	AIO	CAN low	
8	SGND	Power	Signal GND	1
9	IO1(SYNC_IN/PPS)	I/O	Sync Input, accepts external trigger signals (e.g., GNSS PPS)	
10	Vs	Power	Power Input 5-30 V	

Table 6: UART Function Description

UART	Functional
UART1	Primary communication port for data output, command/configuration input, and firmware upgrade
UART2	Secondary communication port with the same functions as UART1; also supports additional feature configurations. See the Command and Programming Manual for details

Note1: HI16M0 does not support UART2

9 SPECIFICATIONS

9.1 Gyroscope

Table 7: Gyroscope Parameters

Parameters	Condition	Product	Min	Nom	Max	Unit	Note
Range		HI16M0	15.625	2000	2000	°/s	
		HI16RX	15.625	2000	4000		
Resolution				16bit	20Bit		
Scale Factor	100°/s	HI16M0		<600	800	ppm	1
		HI16RX		<100	200		
Nonlinearity			-0.05	-	0.05	%Fs	2
Noise Density	Bandwidth 100Hz	HI16M0		0.015		°/s√Hz	3
		HI16RX		0.0025			
3dB Bandwidth		HI16M0		90	200	Hz	
		HI16RX			400		
Zero-rate Output					±0.1	°/s	4
Sampling Rate				1000		Hz	
Bias Instability	Allan Variance	HI16M0		3		°/h	1σ
		HI16RX		1.7			
Bias Stability	10s Average	HI16M0		10		°/h	1σ
		HI16RX		4			
Bias Repeatability		HI16M0		5.3		°/h	
		HI16RX		3.7			
Angle Random Walk	Allan Variance	HI16M0		0.42		°/√h	1σ
		HI16RX		0.1			
Bias over Full Temperature Range	-40-85℃			0.07	0.2	°/s	
g-sensitivity	All three axis			0.05		°/s/g	

Note1: Rotate the rate table 10 turns forward and 10 turns backward.

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

Note3: Mean value of test samples.

Note4: After initial bias calibration, the bias can be estimated in real time by the algorithm engine.

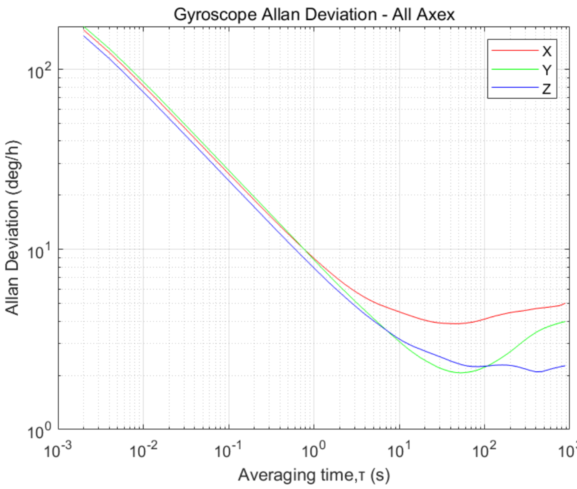


Figure4: HI16M0 Gyroscope Allan Variance

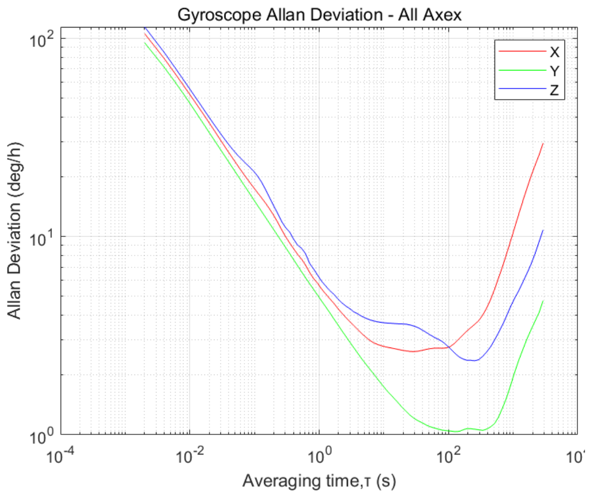


Figure5: HI16RX Gyroscope Allan Variance

9.2 Accelerometer

Table 8: Accelerometer Parameters

Parameters	Condition	Product	Min	Nom	Max	Unit	Note
Range		HI16M0	3	12	16	g	
		HI16RX	2	8	32		
Resolution				16	20	bit	
Initial Bias				2	20	mg	1
Nonlinearity				0.01		%Fs	
3dB Bandwidth		HI16M0		80	200	Hz	
		HI16RX			400		
Noise Density	Bandwidth 100Hz	HI16M0		0.175		mg/√Hz	2
		HI16RX		0.05	0.07		
Sampling Rate				1000		Hz	
Bias Instability	Allan Variance	HI16M0		0.03		mg	1σ
		HI16RX		0.012			
Bias Stability	10s Average	HI16M0		0.07		mg	1σ
		HI16RX		0.015			
Bias Repeatability		HI16M0		0.34		mg	
		HI16RX		0.11			
Random Walk	Allan Variance	HI16M0		0.08		m/s/√h	1σ
		HI16RX		0.018			
Bias over Full Temperature Range	-40-85℃			2.5	5	mg	3

Note1: Average value of test samples.

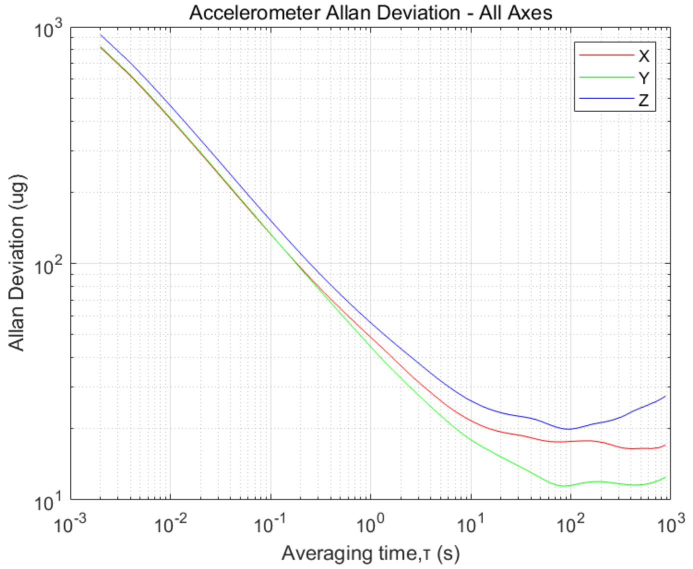


Figure6: HI16M0 Accelerometer Allan Variance

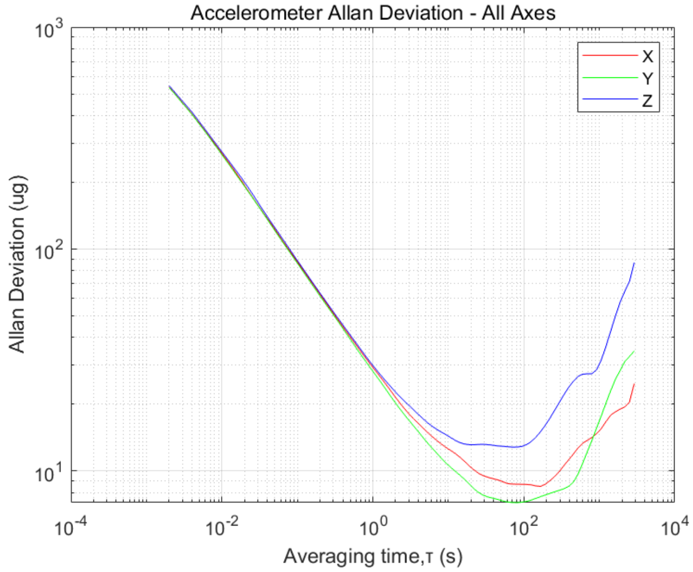


Figure7: HI16RX Accelerometer Allan Variance

9.3 Magnetic

Table 9: Magnetic Parameters

Parameters	Condition	Min	Nom	Max	Unit	Note
Range			20		Gauss	
Sampling Rate			200Hz			
Linearity			0.1		Fs%	

9.4 Temperature

Table 10: Temperature Parameters

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

9.5 Attitude Angle Accuracy

Table 11: Attitude Angle Accuracy

Parameters	Condition	Product	Min	Nom	Max	Unit	Note
Pitch/Roll (static)				0.15	0.2	°	
Pitch/Roll (dynamic)				0.15	0.2	°	
Heading static drift (6DOF)	Stationary for 2 h			0.15	0.2	°	1
Heading dynamic drift (6DOF)		HI16M0 HI16RX		9 5		°	2
Heading dynamic drift (AHRS)		HI16R3		2	3	°	3
Heading rotation error (6DOF)	100°/s	HI16M0 HI16RX		<0.8	3 1.3	°	4

Note1: Module kept level and stationary for 2 hours.

Note2: Measured with the module operating on an indoor cleaning robot for 1 hour. 1σ.

Note3: Measured after geomagnetic calibration and with no surrounding magnetic interference; the product must be configured in AHRS mode.

Note4: Continuous rotation of the rate table for 10 turns; cumulative heading error.

10 SYSTEM & ELECTRICAL

10.1 Electrical Parameters

Parameters	Condition		Min	Nom	Max	Unit	Note
Input Voltage VDD			5	24	26	V	
Power Consumption	HI16M0				200	mW	
	HI16R2				250		
	HI16R3				300		
IO	V_{OL}			-	0.4	V	
	V_{OH}		2.6				
	V_{IL}		-0.3		1		
	V_{IH}		1.9		3.6		
RS-232	V_{IH} Driver high-level input voltage		2			V	
	V_{IL} Driver low-level input voltage				0.8		
	VI	Driver input voltage	0		5.5		
		Receiver input voltage	-25		25		
	Input resistance		3	5	7	kΩ	
	Output resistance		300	10M		Ω	

10.2 Interface Parameters

Interf	Parameters	Condition	Min	Nom	Max	Unit	Note
UART1/UART2	Baud Rate		9600	115200	921600	bps	
	Output Frame Rate	HI16RX	0	100	1000	Hz	
		HI16MX	0	100	200		
CAN	Baud Rate		125K	500K	1M	bps	
	Output Frame Rate		0	100	200	Hz	
	Termination Resistor			None			

10.3 System Parameters

Parameters	Product	Value	Note
Dimension	PCBA	25X26.7X17mm	
	BOX	28.2x28.2x17mm	
Weight	PCBA	<7g	
	BOX	<12g	
Startup Time		2s	1
Operating Temperature		-40-85℃	
Enclosure Material		ABS+PC	
Vibration Resistance		1.0mm(10Hz-58Hz)&≤20g(58Hz-600Hz)	
RoHS Directive 2011/65/EU		RoHS 2011/65/EU	
EMC		LVD Directive 2014/35/EU	
Drop Test		Free drop from a 75 cm-high bench, 3 times	
Thermal Shock		Temperature cycles from -40 ℃ to 85 ℃ within 1 h, 5 cycles	

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

10.4 Absolute Maximum Ratings

Parameters	Limit	Comment
Mechanical Shock	10000g	Duration <0.2ms
Storage Temperature	-40℃-125℃	
ESD HBM	30KV	JEDEC/ESDA JS-001
Input Voltage	30V	
IO To GND	-0.3-5V	
RS-232 TX to GND	±13.2V	
RS-232 RX to GND	±25V	
CAN H or CAN L to GND	±36V	

11 DIMENSIONS

11.1 Dimensions

All Dimensions in mm units

11.1.1 HI16XX-PCBA Dimension

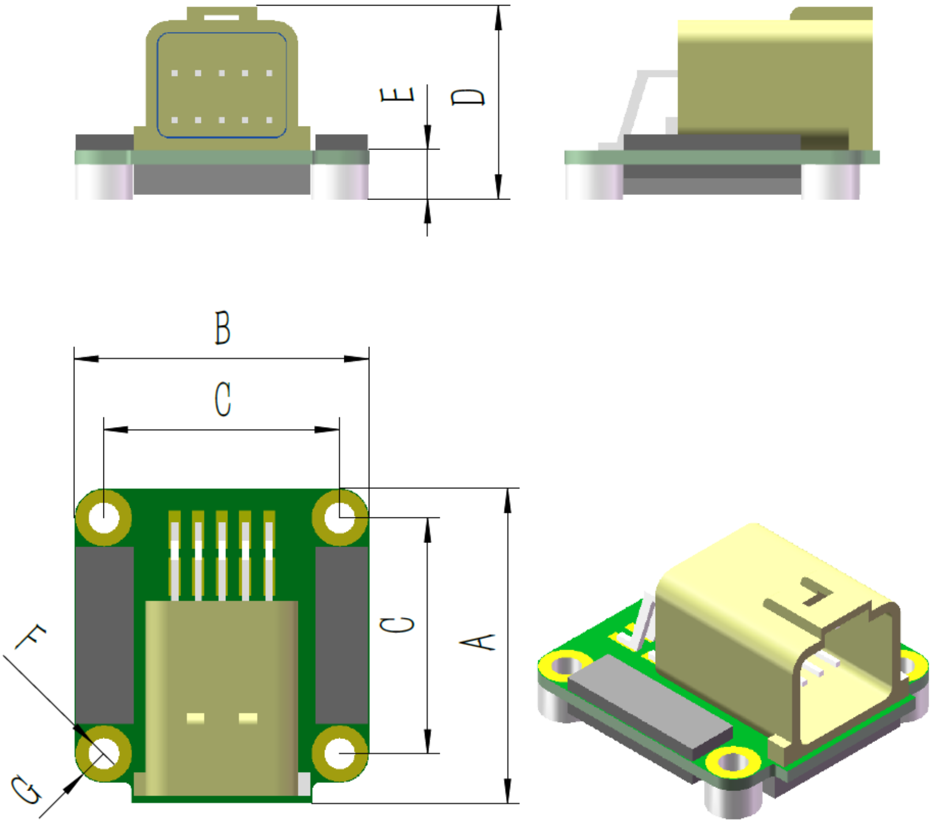


Figure8: HI16XX PCBA Mechanical Specifications

Table 12: HI16XX-PCBA Dimension Table

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	26.4	26.7	27
B	24.7	25	25.3
C	19.9	20	20.1
D	16.7	17	17.2
E	4	4.2	4.4
F	Φ2.5	Φ2.6	Φ2.7
G	R2.3	R2.5	R2.7

11.1.2 HI16XX-BOX Dimension

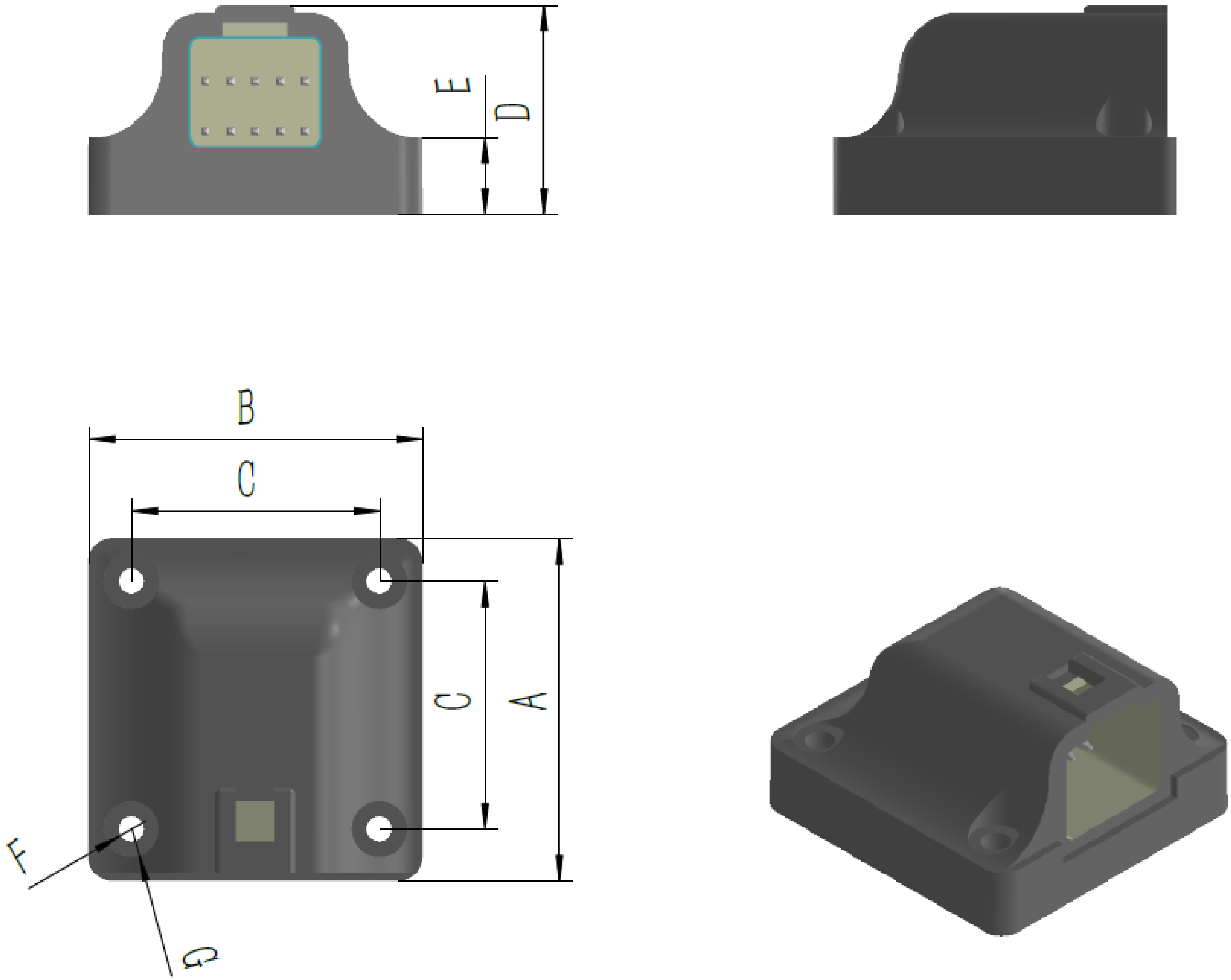


Figure9: HI16XX BOX Mechanical Specifications

Table 13: HI16XX-BOX Dimension Table

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	28	28.2	28.5
B	28	28.1	28.3
C	19.9	20	20.1
D	16.7	17	17.2
E	6.5	6.6	6.7
F	Φ2.5	Φ2.6	Φ2.7
G	R2.1	R2.25	R2.4

12 COORDINATE SYSTEM

12.1 Coordinate System

The body frame uses a Right-Forward-Up (RFU) coordinate system, and the geographic frame uses an East-North-Up (ENU) coordinate system. The accelerometer and gyroscope axes are shown below:

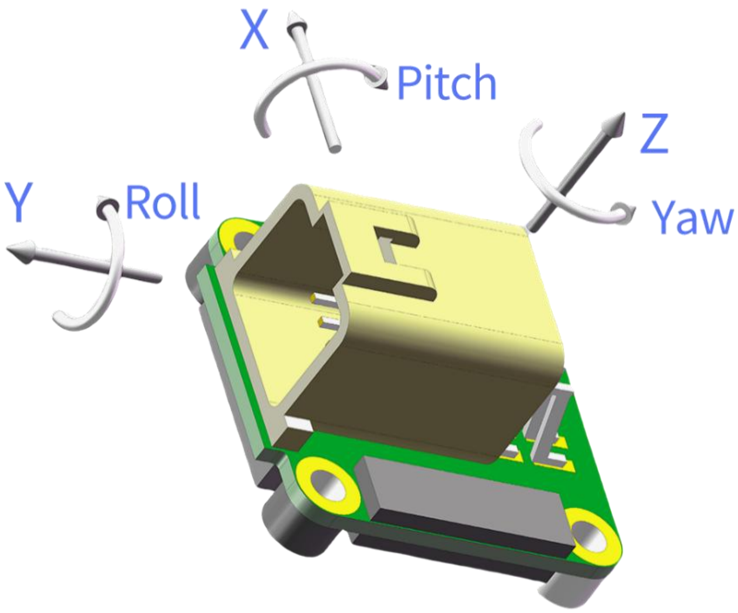


Figure10: HI16 Coordinate System

The Euler angle rotation sequence is ENU-312 (rotate about Z first, then X, and finally Y). Definitions are as follows:

Rotation about the Z axis: Yaw ψ, range: -180° to 180°

Rotation about the X axis: Pitch θ, range: -90° to 90°

Rotation about the Y axis: Roll ϕ, range: -180° to 180°

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

If users need to change the default sensor coordinate system, please refer to the Command and Programming Manual.

12.2 Installation Diagrams

12.2.1 HI16XX-PCBA Installation Example

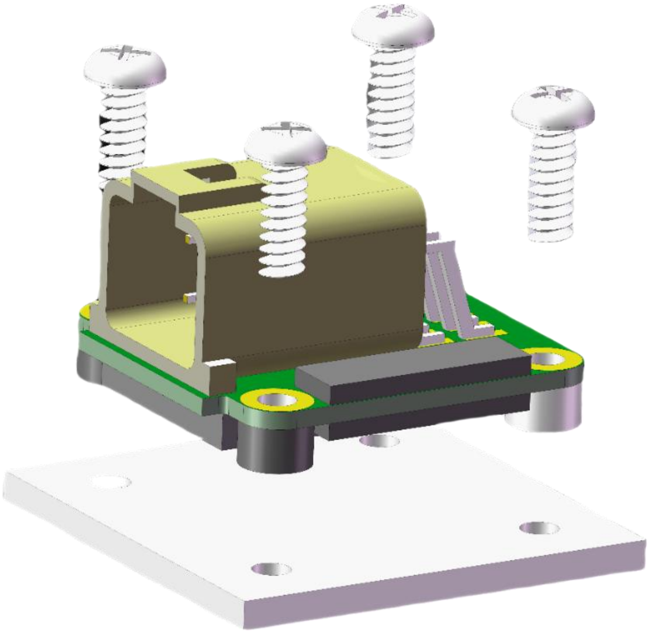


Figure11: HI16XX-PCBA Mounting Example

12.2.2 HI16XX-BOX Installation Example

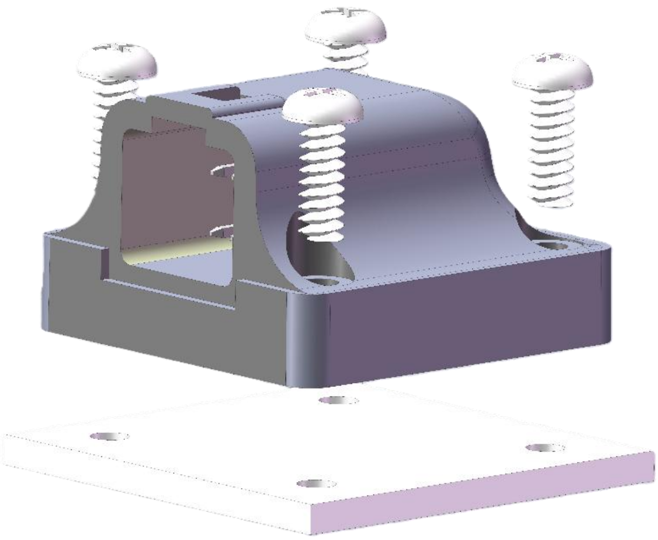
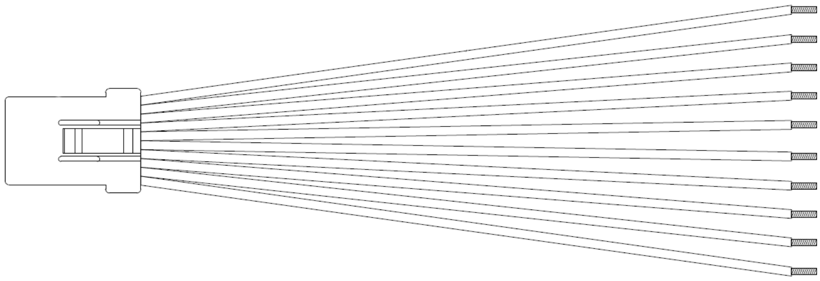
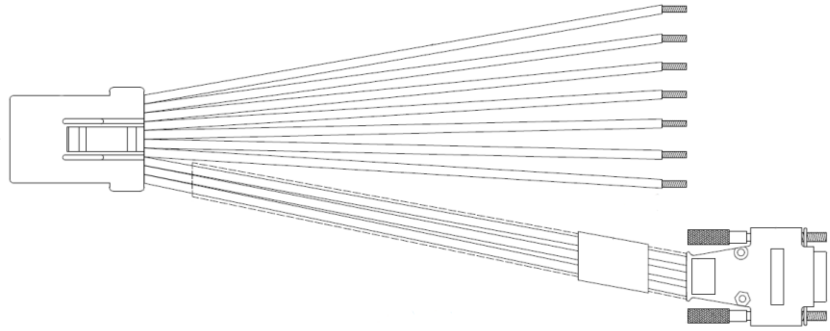


Figure12: HI16XX-BOX Mounting Example

Note1: It is recommended to mount the module at a location with low vibration and small temperature variation on the measured object.
Note2: For other mounting orientations, please refer to the Command and Programming Manual to rotate the coordinate system accordingly.

13 CABLE

Description	Digram	Note
JWPF Female-OPEN		1
JWPF Female-DB9 Female		2

Note1: Cable length options: 0.5 m and 1.5 m

Note2: Default configuration: JWPF female to DB9 female cable length 1.5m

14 CONNECTION

14.1 JWPF Female to OPEN(UART)

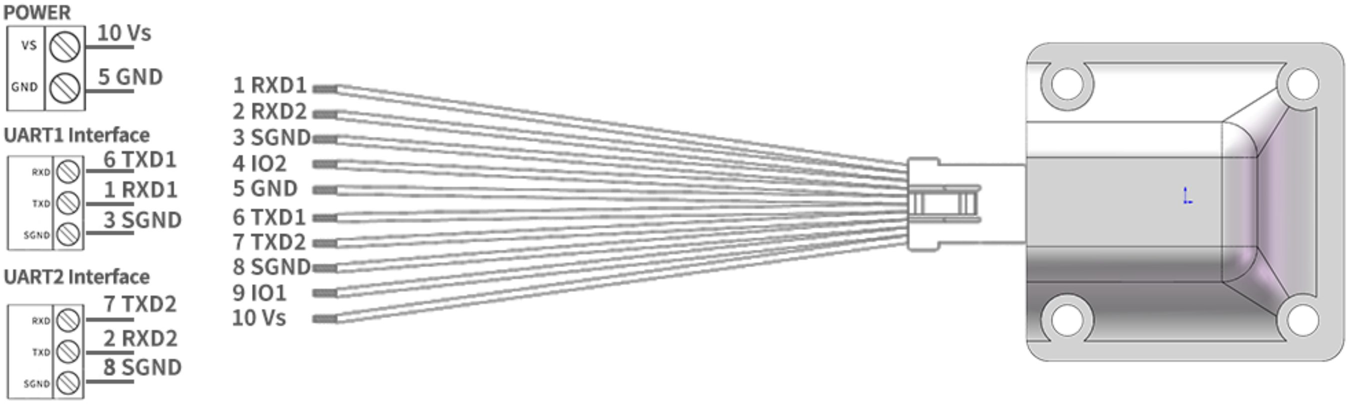


Figure13: JWPF Female to OPEN(UART)

Note1: The UART interface can be TTL or RS-232

Note2: Users may use only one of UART1 or UART2; UART1 is used by default.

14.2 JWPF Female to OPEN(RS-232+CAN)

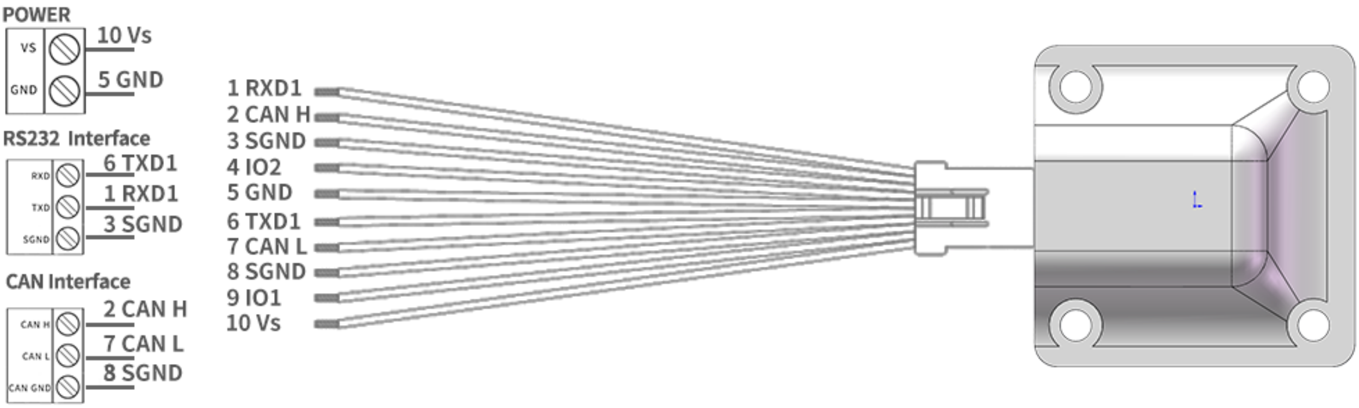


Figure14: JWPF Female to OPEN(RS232+CAN)

14.3 JWPF Female to OPEN(Synchronized Trigger)

14.3.1 UART+GPRMC/UTC Synchronization

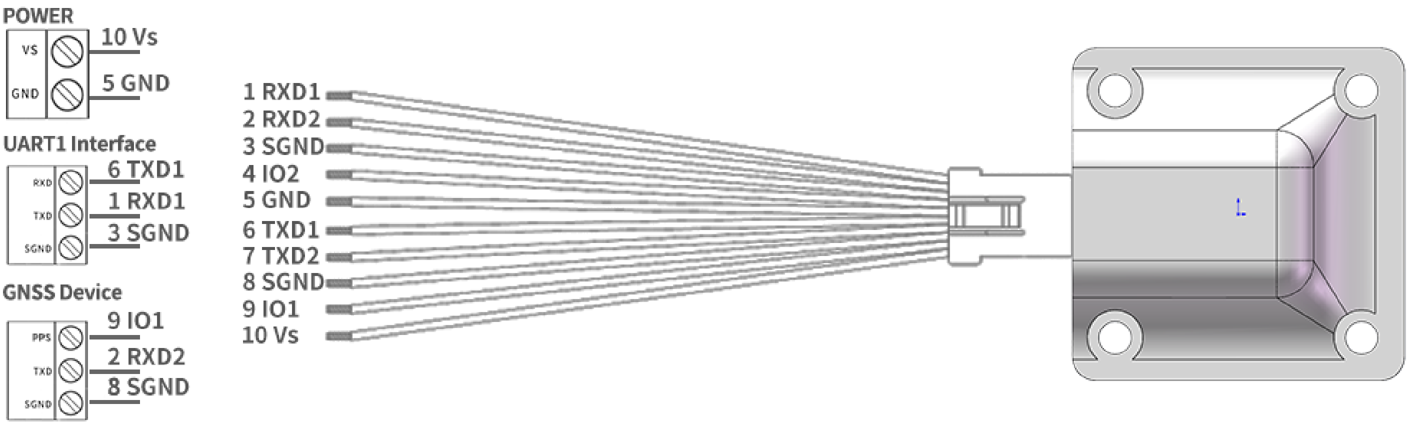


Figure15: JWPF Female to OPEN(UART+UTC/GPRMC Synchronization)

14.3.2 Pulse Trigger

In addition to PPS time synchronization, HI16 also supports pulse triggering. Pulses support synchronized input IO1 (SYNC_IN) and synchronized output IO2 (SYNC_OUT).

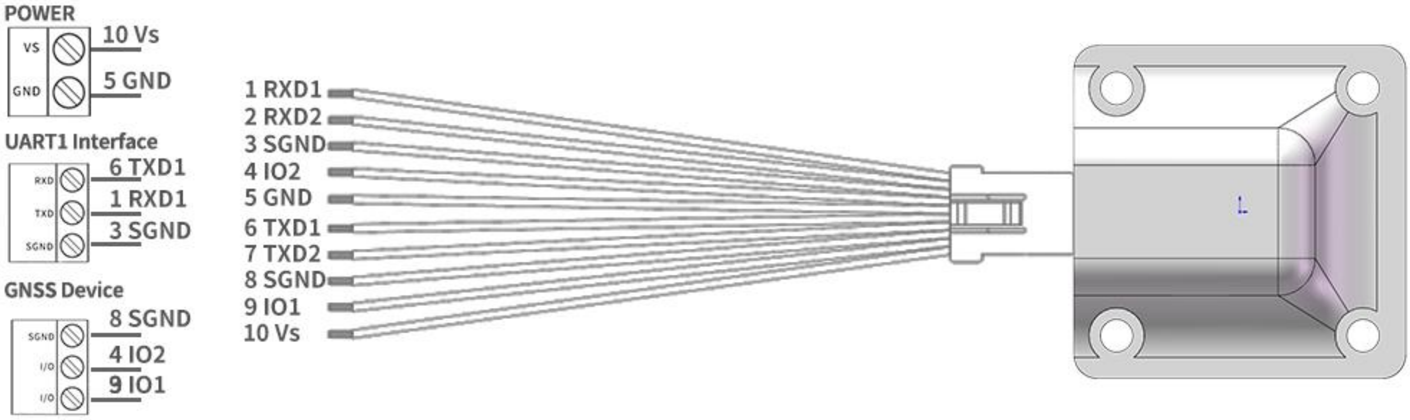


Figure16: JWPF Female to OPEN(UART+UTC/GPRMC Synchronization)

Note1: If the user employs the synchronized input IO1, the host must output a pulse signal at the same frequency as the data frame rate. For example, for 100 Hz data, the trigger pulse must also be 100 Hz.

Note2: If the user uses IO2, the IO2 output frequency is synchronized with the data frame rate; IO2 is equivalent to a Data Ready signal.

15 PROTOCOL

15.1 Serial Binary Protocol

To facilitate user integration, we provide a rich set of serial protocols for selection. For detailed information, please refer to the Command and Programming Manual.

15.2 CAN

CAN communication supports CANopen and SAE J1939. For details, please refer to the Command and Programming Manual.

16 FAQ

16.1 Serial Port Issues

There are many reasons why the IMU cannot be configured or the IMU data cannot be correctly received. The most typical scenarios include the following:

1. IMU's serial port is not cross-connected with the host's serial port

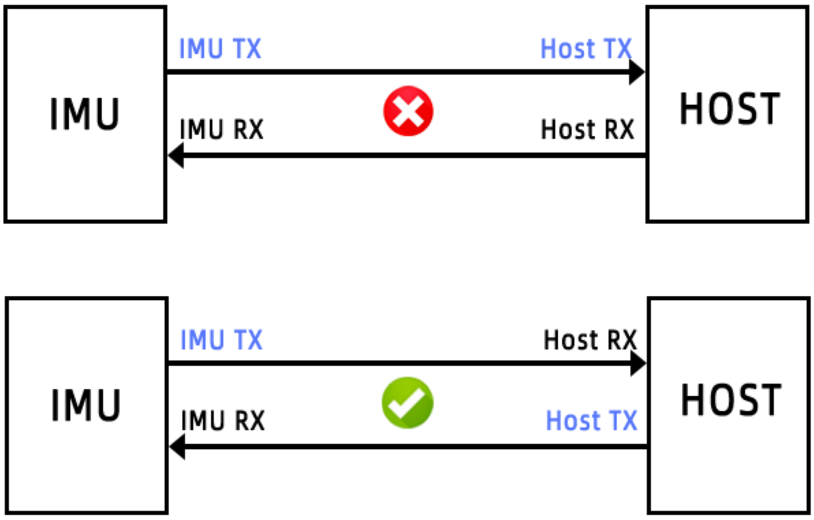


Figure17: IMU serial port connected to a single host

2. Incorrect serial port configuration

Serial port configurations include many parameters such as baud rate, start bit, data length, parity, and stop bit. The default configuration can be referenced in Chapter 10.1. The most common error is mismatched baud rates, especially when users change the IMU's baud rate but forget to adjust the host's baud rate accordingly. The phenomenon is that the IMU cannot be configured and IMU data cannot be received, as shown in the figure below:

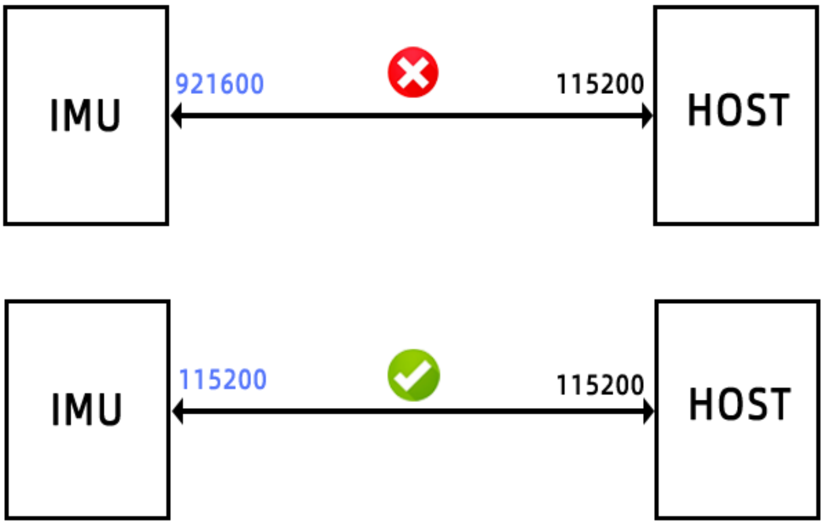


Figure18: IMU serial port connected to a single host

Note3: The above baud rate issue also applies to the CAN interface. The CAN interface also requires the IMU and the user's host to have matching baud rates.

3. IMU's receive (RX) is simultaneously connected to multiple devices' transmit (TX)

Sometimes, users unknowingly connect the serial port to two host devices. In this case, both of the user's hosts will receive IMU data, but the IMU cannot be configured. The most typical scenario is when the IMU is mistakenly connected to both the user's host and our upper computer software, as shown in Figure 27:

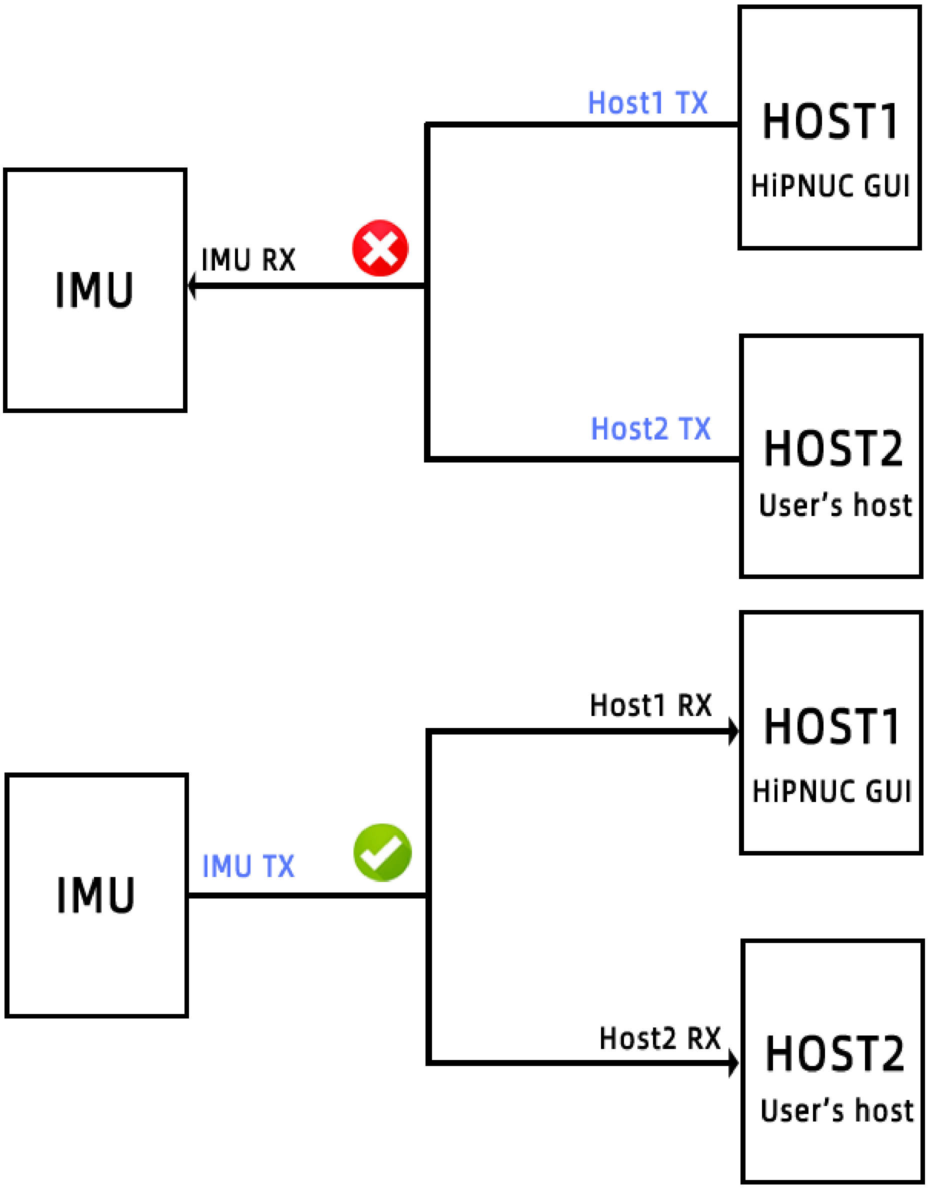


Figure19: IMU serial port simultaneously connected to the user's host and HiPNUC GUI

4. Software issues

The user's receiving program may not be robust, such as failing to correctly parse data or mismatched CRC checks, which can result in the inability to correctly receive and configure IMU data. In this case, please refer to our official parsing examples or contact us for technical support.

5. Other issues

Hardware issues such as cold solder joints or loose connections, excessively long or poor-quality cables can cause problems. We recommend prioritizing the use of the USB-to-serial cable we provide for users. Our cables are designed to accommodate full-scenario user applications.