User Manual

YIS320
Attitude sensor

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Revisions

Revision	Date	Changes
1.3	2023-06-12	• Add USB communication interface description
1.2	2023-03-06	• Update some content
1.1	2022-12-05	• Revise relevant content and description
1.0	2022-08-02	• Initial release

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Before ordering products, please contact our company or local distributors for the latest specifications.

Contents

1. Product introduction

1.1 Overview

YIS320 is a high-precision attitude sensor that can measure the three-dimensional attitude angle (including static and dynamic inclination), acceleration, angular velocity, and magnetic field strength information of the carrier.

YIS320 integrates an industrial grade, highly reliable three-axis MEMS gyroscope, three-axis MEMS accelerometer, and three-axis magnetic sensor through the embedded YFusion® high-performance attitude fusion algorithm, high-precision sensor error compensation algorithm, and strict factory testing calibration can achieve measurement accuracy of 0.05° roll and pitch angle, as well as measurement accuracy of 0.2° no reference heading angle and 1° magnetic reference heading angle.

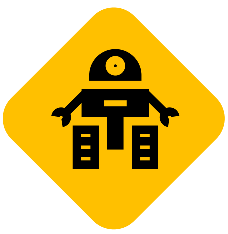
YIS320 adopts a small-sized design of 22.4 × 22.4 × 9.4mm, supports UART and USB interface communication, and provides corresponding SDKs to facilitate user integration of applications and shorten development period.

Fig 1 YIS320

1.2 Features

- 0.05° roll and pitch angle accuracy
- 0.2° accuracy of no reference heading angle
- 1° magnetic reference heading angle accuracy
- 22.4 x 22.4 x 9.4mm small size
- UART and USB interface communication

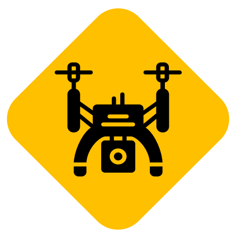
1.3 Applications



Robot

Unmanned vehicle

Handheld device



Stabilized platform

2. Specifications

2.1 Attitude specifications

Specification		Typical value	Remark
Roll angle	accuracy[1,2]	0.05°	1σ RMS
	range	±180°	
Pitch angle	accuracy[2]	0.05°	1σ RMS
	range	±90°	
No reference yaw heading[3]	accuracy[4]	0.2°	1σ RMS
	range	±180°	
magnetic reference heading[5]	accuracy[6]	1°	1σ RMS
	range	±180°	
angular resolution[7]		0.001°	

2.2 Gyroscope specifications

Specification	Typical value	Remark
Full scale	±450°/s	Up to ±2000°/s
Non-Linearity	±0.05%FS	
Noise density	0.015°/s/√Hz	
Bias instability[8]	5°/h	Allan variance, 1σ
Bandwidth(-3dB)	50Hz	

[1] The accuracy in this manual refers to the root mean square (RMS) error between the actual angle and the sensor-measured angle through multiple measurements. Unless otherwise specified, measurements are taken at 25°C.

[2] Measure under static and moderate dynamic motion conditions without prolonged acceleration.

[3] The default output heading angle of this product is no reference heading angle when it leaves the factory. The non reference heading angle, also known as the relative heading angle, refers to the change in heading angle compared to the moment of power on, where the heading angle at the moment of power on is defaulted to 0 °.

[4] When rotating 360° around the Z-axis at 100°/s, the error generated is <0.06%. Due to inherent device drift characteristics, the error may increase over time (<0.5%). The non-referenced heading angle drifts over time:Typical 1-hour drift in indoor robotic motion scenarios: <5°. Typical 1-hour drift under static conditions: <0.1°. All long-term drift data above were measured in laboratory environments.

[5] The magnetically referenced heading angle uses Earth's magnetic field as a reference. While the default output is the non-referenced heading angle, refer to Section 6.7.2 for using the magnetically referenced version.

[6] The test is conducted in a stable magnetic field environment and the magnetic sensor has been calibrated on site.

[7] The minimum detectable angular change within the sensor's measurement range defines its resolution.

[8] Reference: 《IEEE Std 952™-1997 (R2008) IEEE Standard Specification Format Guide and Test Procedure for Single Axis Interferometric Fiber Optic Gyros》.

Zero-rate offset	±0.5°/s	1σ RMS
Zero-rate offset change over temperature	±1°/s	1σ RMS, -40~85°C

2.3 Accelerometer specifications

Specification	Typical value	Remark
Full scale	±16g	
Non-Linearity	±0.1%FS	
Noise density	100ug/√Hz	
Bias instability[9]	0.035mg	Allan variance, 1σ
Bandwidth(-3dB)	50Hz	
Zero-rate offset	±20mg	1σ RMS
Zero-rate offset change over temperature	±10mg	1σ RMS, -40~85°C

2.4 Magnetometer specifications

Specification	Typical value	Remark
Full scale	±8Gauss	
Non-Linearity	±0.1%FS	FS = ±8G
Noise	0.4mGauss	RMS

2.5 Physical and electrical specifications

Specification	Typical value	Remark
Input voltage	5VDC	⩽30mV peak-peak
Power consumption	190mW	@5V
Communication interfaces	UART	YIS320-E11
	USB	YIS320-E30
Protocols	Yesense YIS protocol	Yesense private protocol
Output rate	200Hz	Up to 400Hz
Size	22.4×22.4×9.4mm	
Weight	7.7g	±1g
Shell material	Aluminum	

[9] Reference: 《IEEE Std 952™-1997 (R2008) IEEE Standard Specification Format Guide and Test Procedure for Single Axis Interferometric Fiber Optic Gyros》.

2.6 Environment specifications

Specification	Typical value	Remark
Operating temperature	-40~85°C	
Storage temperature	-45~85°C	relative humidity ≤ 65%
Shock limit	2000g	

3. Mechanical structure

All dimensions are in mm.

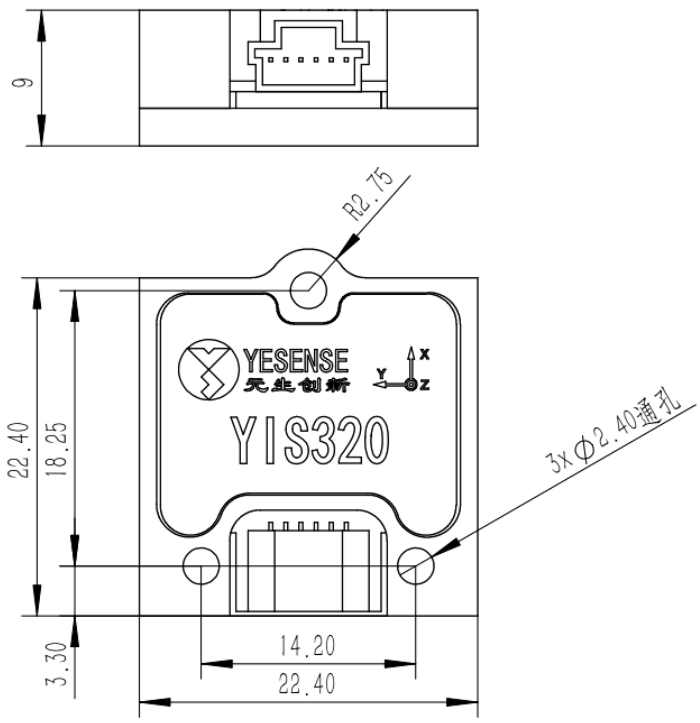


Fig 2 Mechanical dimension of YIS320

4. Coordinate frames and installation instructions

4.1 Coordinate system definition

The coordinate system definition of YIS320 is shown in the following figure。Rotation around the X-axis corresponds to the roll angle, rotation around the Y-axis corresponds to the pitch angle, and rotation around the Z-axis corresponds to the heading angle. Under the right-hand rule, the thumb points in the direction of the rotation axis, and the angle increases when rotating in the positive direction of rotation.

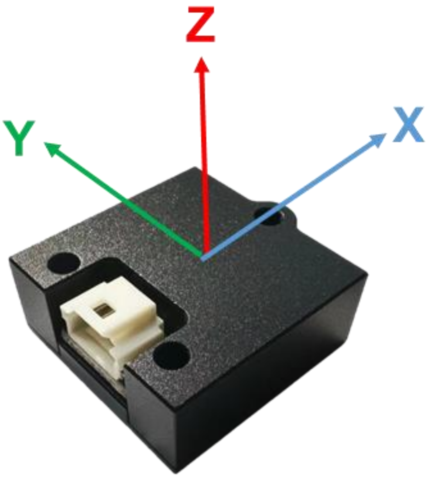
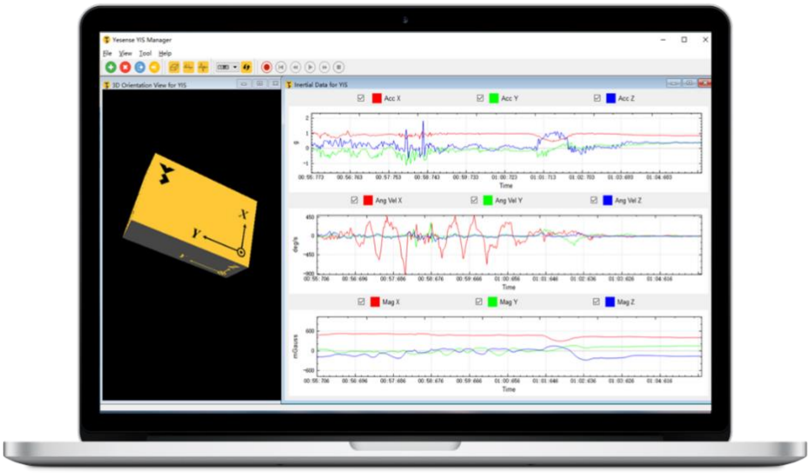


Fig 3 YIS320 body coordinate frame

5. Accessories

In order to facilitate quick evaluation by users and shorten the development cycle, YIS320 comes with connecting cables, upper computer software (YESENSE YIS Manager, as shown in the figure below), related routine parsing codes, etc. You can contact sales personnel to obtain them.



The length of the connecting cables for YIS320 is 1m.One end of the bare wire connector of YIS320 is a female connector that matches the YIS320 interface, and the other end is a bare wire connector. The cable schematic and pin definitions are as follows:

Pin color	Definition	Remark
Red	VCC	5V
Black	GND	Ground
White	TXD	TTL
Green	RXD	TTL
Yellow	NC	
Blue	NC	

One end of the YIS320 USB TYPE-A male connector is a female connector that matches the YIS320 interface, and the other end is a USB TYPE-A male connector. The cable schematic and pin definitions are as follows:

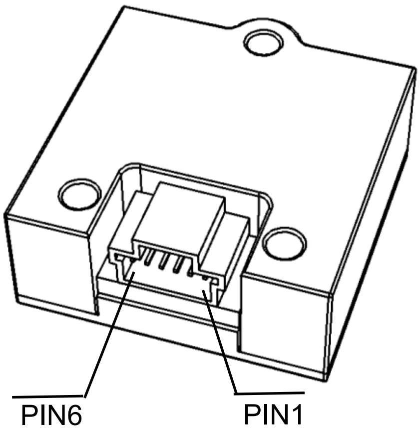
Pin color	Definition	Remark
Red	VCC	5V
Black	GND	Ground
White	USB_DM	
Green	USB_DP	
Yellow	NC	
Blue	NC	

You can contact our sales personnel if you need other forms of connecting cables or related accessories for bulk procurement.

6. Communication interface and protocol

6.1 Overview

The external interface of YIS320 uses a 6Pin male connector with a lock buckle with a spacing of 1.0mm. The interface pins are defined as shown in the following figure:



No.	Definition	Description
1	VCC	5VDC，noise≤30mV peak-peak
2	GND	
3	UART_TX/USB_DM	Serial port sending pin, TTL level/USB data negative pole
4	UART_RX/USB_DP	Serial port receiving pin, TTL level/USB data positive pole
5	NC	Non-electrical connection
6	NC	Non-electrical connection

6.2 Communication interface

6.2.1 UART communication interface

The YIS320 supports UART interface and following baud rates:

- 9600 bps
- 38400 bps
- 115200 bps
- 460800 bps (default)
- 921600 bps

The complete UARTinterface parameters are as follows:

Parameter	Value
Data bit	8

Stop bit	1
Parity	None
Flow Control	None

The electrical characteristics of the transceiver are as follows:

Parameter	Min.	Typ.	Max.	Unit
TXD Low level threshold	0		0.4	V
TXD High level threshold	2.4		3.3	V
RXD Low level threshold	-0.3		0.8	V
RXD High level threshold	1.7		3.6	V

6.3 Protocol frame format

The Yesense private output protocol adopts a fixed format, and the frame structure includes five parts: frame header, timestamp, data length, data, and checksum, as shown in the table below.

Type	LEN (Bytes)	Description
YS Header	2	The starting frame of the data packet，0x59,0x53
TID	2	Time stamp identification
LEN	1	The length of Message, with a maximum value of 255
MESSAGE	0-255	The valid data of the packet
CK1	1	Checksum
CK2	1	Checksum

6.4 Valid data definition rules

The definition of MESSAGE is shown in the table below:

Packet 1			……	Packet N		
DATA ID	LEN	DATA (LEN Bytes)	……	DATA ID	LEN	DATA (LEN Bytes)

The data in MESSAGE can be composed of a combination of multiple Packets. Each different Packet contains a specific DATA ID and its corresponding data length indicator LEN, as well as data DATA with a data length of LEN.

The correspondence between DATA ID and LEN and DATA is shown in the table below.

Type	ID	Length	Content
IMU temperature[10]	0x01	2	DATA1 – DATA2
Acceleration	0x10	12	DATA1 – DATA12
Angular velocity	0x20	12	DATA1 – DATA12
Normalized value of magnetic field[10]	0x30	12	DATA1 – DATA12
Value of magnetic field[10]	0x31	12	DATA1 – DATA12
Euler angles	0x40	12	DATA1 – DATA12
Quaternion	0x41	16	DATA1 – DATA16

The DATA conversion relationship is shown in the following table.

Type	Data	Data transformation	Unit
IMU temperature	DATA1（DATA[7:0]）	temp_imu = DATA ×0.01	˚C
	DATA2（DATA[15:8]）		
Acceleration	DATA1（DATA[7:0]）	ax = DATA × 0.000001	m/s²
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	ay = DATA × 0.000001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	az = DATA × 0.000001	
	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		
Angular velocity	DATA1（DATA[7:0]）	wx = DATA × 0.000001	deg/s
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	wy = DATA × 0.000001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	wz = DATA × 0.000001	

[10] By default, there is no output, but it can be configured through instructions. Please refer to《Yesense Communication Protocol》for details.

	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		
Normalized value of magnetic field	DATA1（DATA[7:0]）	mx = DATA × 0.000001	
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	my = DATA ×0.000001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	mz = DATA ×0.000001	
	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		
Value of magnetic field	DATA1（DATA[7:0]）	mx = DATA × 0.001	mGauss
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	my = DATA × 0.001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	mz = DATA × 0.001	
	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		
Euler angles	DATA1（DATA[7:0]）	pitch = DATA × 0.000001	deg(°)
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	roll = DATA × 0.000001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	yaw = DATA × 0.000001	
	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		

Quaternion	DATA1（DATA[7:0]）	q0 = DATA × 0.000001	
	DATA2（DATA[15:8]）		
	DATA3（DATA[23:16]）		
	DATA4（DATA[31:24]）		
	DATA5（DATA[7:0]）	q1 = DATA × 0.000001	
	DATA6（DATA[15:8]）		
	DATA7（DATA[23:16]）		
	DATA8（DATA[31:24]）		
	DATA9（DATA[7:0]）	q2 = DATA × 0.000001	
	DATA10（DATA[15:8]）		
	DATA11（DATA[23:16]）		
	DATA12（DATA[31:24]）		
	DATA13（DATA[7:0]）	q3 = DATA × 0.000001	
	DATA14（DATA[15:8]）		
	DATA15（DATA[23:16]）		
	DATA16（DATA[31:24]）		

6.5 Checksum calculation

A complete data frame requires an additional checksum, which is calculated from TID to the last byte of the Message, as shown in the table below. The calculation formula is shown in the example below.

YS Header	TID	LEN	MESSAGE	CK1	CK2

Range over which the checksum is to be calculated

Assuming there are N bytes (buffer [N]) within the verification range, the calculation formula is as follows:

```
CK1 = 0； CK2 = 0；
For(i=0;i<N;i++)
{
    CK1 = CK1 + buffer[i];
    CK2 = CK2 + CK1;
}
```

6.6 UART interaction protocol frame format

The format of the YIS320 interactive instruction protocol is different from the default message output format. The frame structure includes: frame header, data class, operator, data length, data field, and checksum. As shown in the table below.

Type	LEN (Bytes)	Description
Frame header	2bytes	Starting frame of YIS packet, 0x59,0x53
Data class	1byte	Data category
Operator	3bits	Query or Write
Data length	13bits	The length of the data, with a maximum value of 8191
Data	0-8191bytes	The valid data of the packet
CK1	1byte	check code
CK2	1byte	

6.6.1 Checksum calculation

A complete data frame requires an additional checksum, which is calculated from the beginning of the data class to the last byte of the data field, as shown in the following table.

Frame header	Data class	Operator (2:0)	Data length (15:3)	Data	CK1	CK2
0x59 0x53	← Range over which the checksum is to be calculated →					

Assuming there are N bytes (buffer [N]) within the verification range, the calculation formula is as follows:

```
CK1 = 0；CK2 = 0；
For(i=0;i<N;i++)
{
    CK1 = CK1 + buffer[i];
    CK2 = CK2 + CK1;
}
```

6.7 Communication baud rate configuration

The following baud rate configurations are supported by YIS320.

Description		Command（HEX）	Reference return value（HEX）
Baud rate	9600 bps	59 53 02 0A 00 01 0D 27	Null
	19200 bps	59 53 02 0A 00 06 12 2c	Null
	38400 bps	59 53 02 0A 00 02 0E 28	Null
	57600 bps	59 53 02 0A 00 07 13 2d	Null
	115200 bps	59 53 02 0A 00 03 0F 29	Null
	230400 bps	59 53 02 0A 00 09 15 2F	Null
	460800 bps	59 53 02 0A 00 04 10 2A	Null
	921600 bps	59 53 02 0A 00 05 11 2B	Null

Notes：

1. The baud rate setting needs to consider the single frame data output and output frequency. If the baud rate is set too low without changing the output content, it may result in incomplete data output and unsuccessful configuration. When setting the output content and frequency, if the communication parameters cannot meet the output requirements, it will lead to unsuccessful configuration. The minimum baud rate can be estimated using the following formula:
2. Estimate a single frame data transfer time t = 1/f * 1000 – 1 (ms)
   f: output frequency.
3. Estimate the baudrate = n * 10 * 1000 / t
   n: the number of bytes in a single frame of data.
   baudrate: To ensure that commands can be received normally after modifying the baud rate, it is recommended to set the value below 80% of the desired baud rate. After setting the baud rate, please connect to YIS320 using the newly set baud rate.

6.8 Output frequency configuration

The following output frequency configurations are supported by YIS320.

Description		Command（HEX）	Reference return value（HEX）	
Output frequency	1Hz	59 53 03 0A 00 01 0E 2B	successful	59 53 03 0A 00 00 0D 2A
	2Hz	59 53 03 0A 00 02 0F 2C		
	5Hz	59 53 03 0A 00 03 10 2D		
	10Hz	59 53 03 0A 00 04 11 2E		
	20Hz	59 53 03 0A 00 05 12 2F		
	25Hz	59 53 03 0A 00 06 13 30	failed	59 53 03 0A 00 FF 0C 29
	50Hz	59 53 03 0A 00 07 14 31		
	100Hz	59 53 03 0A 00 08 15 32		
	200Hz	59 53 03 0A 00 09 16 33		
	400Hz	59 53 03 0A 00 0A 17 34		

6.9 Output content modification

The output content can be modified, and the following output content settings are supported.

Description	Command（HEX）	Reference return value（HEX）

Output content	Acceleration and angular velocity	59 53 04 12 00 C0 00 D6 DC	Successful: 59 53 04 0A 00 00 0E 2E Failed: 59 53 04 0A 00 FF 0D 2D
	Acceleration, angular velocity, temperature	59 53 04 12 00 C0 04 DA E0	
	Acceleration, angular velocity, quaternion, Euler angle	59 53 04 12 00 D8 00 EE 0C	
	No output	59 53 04 12 00 00 00 16 5C	

Note：For full command function, please contact technical support.

6.10 Commonly used command

6.10.1 Static bias calibration

Due to the inherent characteristics of zero offset in MEMS sensors, such as heading drift caused by excessive gyroscope zero offset during initial power on, the zero offset calibration function can be used. This command corrects the zero offset of the sensor in a stationary state, directly subtracting the zero output error from the sensor's original value. After the module receives the command, the sensor's static angular velocity output will approach zero. After the module is powered on for about 10 seconds, keep it stationary for more than 1 second after sending the command to the module.

Static bias calibration command：59 53 4d 12 00 50 01 b0 6a

Returned value：59 53 4D 0A 00 00 57 52

6.10.2 Heading mode switching

To meet the needs of different application scenarios, YIS320 supports mode switching between non reference heading and magnetic reference heading.

No reference heading angle command: 59 53 4d 12 00 02 63 cm

Return value: 59 53 4D 0A 00 00 00 57 52

Magnetic reference heading angle command: 59 53 4d 12 00 02 01 62 ce

Return value: 59 53 4D 0A 00 FF 56 51

6.11 Firmware upgrade

YIS320 supports firmware upgrade. The user can use the YESENSE YIS Manager host computer or the user's host computer to use this feature.

When upgrading firmware through the user's host, it is necessary to reserve a serial port (including USB virtual serial port) to communicate with the PC on the user's host. When communicating with the PC, the user's host needs to enter transparent mode, forward all data from the PC, and interact with YIS320 to complete the firmware upgrade.

7. Ordering information

Product model	Communication protocol	Supply voltage	Remark
YIS320-E11	UART	5V	
YIS320-E30	USB	5V	

If you have customized needs, please contact our sales staff.