



V1.4

HIGH PRECISION DYNAMIC TILT SENSOR **HDA446T-CANBUS**

Technical Manual

***HDA446T CANBUS TYPE* HIGH PRECISION DYNAMIC TILT SENSOR**

○ Revised: 2025-7-28

Note: Product functions, parameters, appearance, etc. will be adjusted with the technical upgrade, please contact the company for pre-sales business confirmation when purchasing.

Disclaimer

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● PRODUCT DESCRIPTION

The HDA446T product is a new generation of digital MEMS dynamic tilt sensor, which can measure the attitude parameters (roll, pitch, and azimuth) of a moving carrier and is suitable for tilt measurement in motion or vibration states. The HDA446T is equipped with built-in acceleration and gyroscope sensors, and integrates the Kalman filter algorithm to measure real-time motion data of the carrier under motion or vibration conditions. The product has dual CAN (CAN2.0A/CAN2.0B) modes and strong scalability.

This product adopts non-contact measurement principle, it can output the current posture inclination angle in real time. It is easy to use and does not require retrieving the installation of two surfaces with relative changes. Internally integrated high-precision AD and gyroscope units can compensate for nonlinearity, orthogonal coupling, temperature drift, and centrifugal acceleration in real time, greatly eliminating centrifugal errors caused by motion acceleration interference, improving product dynamic measurement accuracy, and adapting to work in complex motion scenes and harsh environments for a long time. This product belongs to the dual-mode measurement sensor of dynamic and static, with strong resistance to external electromagnetic interference. It is suitable for various large-scale high-intensity impact vibration industrial environments and is an ideal choice for industrial automation control measurement posture.

● MAIN FEATURES

- ★ Range (Roll angle $\pm 180^\circ$, pitch angle $\pm 90^\circ$, azimuth angle $\pm 180^\circ$)
- ★ Roll&Pitch Dynamic accuracy: $\pm 0.1^\circ$
- ★ Wide temperature operation $-40^\circ\text{C} \sim +85^\circ\text{C}$
- ★ Static accuracy of roll and pitch: $\pm 0.05^\circ$
- ★ DC 9~36V wide voltage input
- ★ CAN2.0A/CAN2.0B output Optional
- ★ IP67/IP68 Protection Optional

● APPLICATION FIELD

- ★ High vibration impact crushing equipment
- ★ Underground drilling rig attitude navigation
- ★ Geological equipment tilt monitoring
- ★ Ship navigation attitude measurement
- ★ Satellite communication vehicle attitude detection
- ★ Satellite antenna star search
- ★ Railway locomotive monitoring
- ★ Oil drilling equipment
- ★ Shield pipe jacking application



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● SPECIFICATIONS

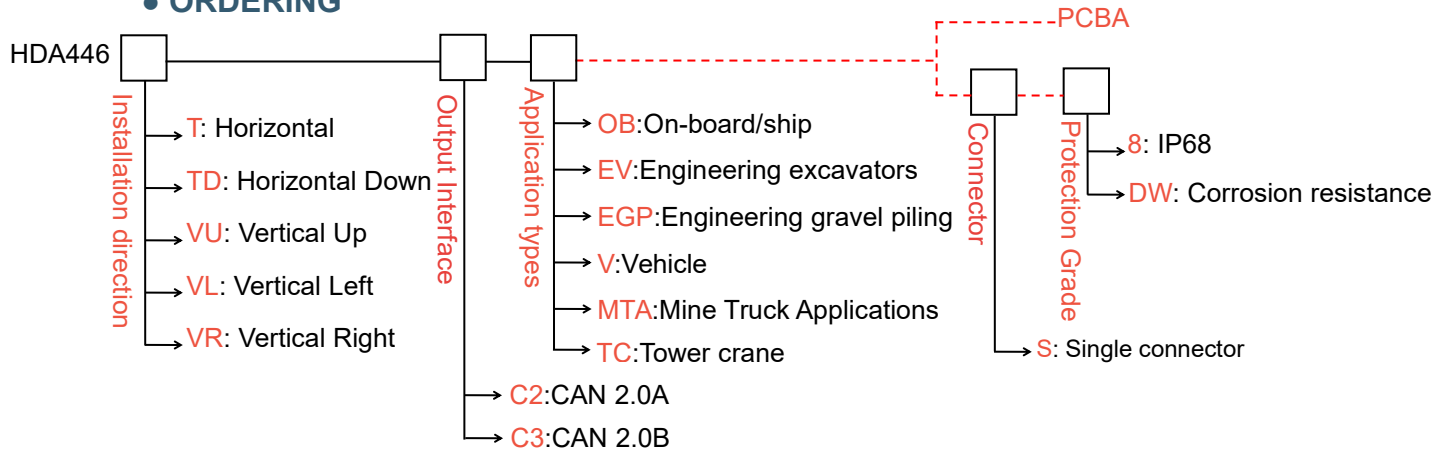
HDA446T-C2/C3		Condition	Parameter
Measure range		\	Roll $\pm 180^\circ$, pitch $\pm 90^\circ$, azimuth $\pm 180^\circ$ (initial value at power-down is 0°)
Measure axis		\	X axis / Y axis / Z axis
Roll&Pitch Static accuracy		@25°C	$\pm 0.05^\circ$
Roll&Pitch Dynamic accuracy (RMS) ¹⁾		@25°C	$\pm 0.1^\circ$
Gyro	range	-	$\pm 300^\circ/\text{s}$
	Zero bias stability (10s smooth)	-	$8.5^\circ/\text{h}$
	Angle random walk coefficient(Allan)	-	$0.25^\circ/\sqrt{\text{h}}$
Acceleration	range	-	$\pm 4\text{g} / \pm 16\text{g}$ optional
	Bias stability(10s mean)	-	0.02mg
	Bias instability(Allan)	-	0.005mg
	Speed random walk coefficient(Allan)	-	$0.005\text{m/s}/\sqrt{\text{h}}$
Zero point temp. Coefficient ²⁾		-40~85°C	$\pm 0.01^\circ/\text{C}$
Sensitivity temp. Coefficient ³⁾		-40~85°C	$\leq 100\text{ppm}/\text{C}$
Power-on startup time			$\leq 3.5\text{S}$
Response time			0.01S
Output signal			CAN2.0A/CAN2.0B
Electromagnetic compatibility			According to EN61000 and GBT17626
MTBF			≥ 98000 hours / time
Insulation resistance			≥ 100 Megohm
Impact resistance			100g @ 11ms, 3 axial direction (half sinusoid)
Anti-vibration			10grms / 10~1000Hz
Waterproof level			Standard IP67, optional IP68 and corrosion-resistant IP68 protection level
Weight			Single connector $\leq 165\text{g}$ / double connector $\leq 180\text{g}$ (Without cable)
¹⁾ Accuracy: refers to the root mean square difference between the measured and actual angle value by multiple measurements (>16 times) under normal temperature. ²⁾ Zero temp. drift coefficient: the change rate of the indication value relative to normal temperature within the rated operating temperature range of the sensor at the zero degree. ³⁾ Sensitivity temp. drift coefficient: The percentage change rate with temperature of the full-scale indication relative to the full-scale indication at room temperature of the sensor in its rated operating temperature range.			

● ELECTRICAL PARAMETERS

Parameter	Condition	Min	Typ		Max	Unit
Supply voltage	standard	9	12	24	36	V
Working current	without load		40mA(12V)			mA
Operating temp		-40			+85	°C
storage temp		-40			+85	°C

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• ORDERING

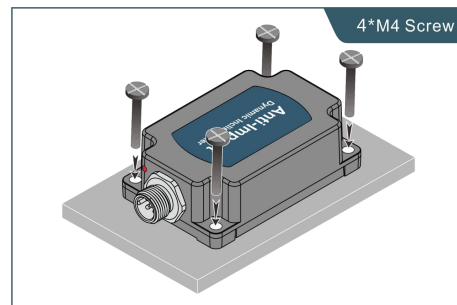


E.g: HDA446T-C2-OB: Standard industrial scenario / Horizontal Installation / CAN 2.0A output interface / On-board/ship Application.

- Note: 1. This product is a double connector (male and female) by default. **If you need a single connector (male), you need to add S before ordering**, for example: HDA446T-C2-OB-S;
2. The default protection level of this product is IP67. **If a higher protection level is required**, for example: HDA446T-C1-OB-8;
3. If only PCBA board is needed, add PCBA after selection, for example: HDA446T-C2-OB-PCBA.

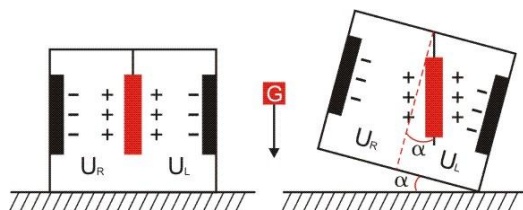
• MECHANICAL PARAMETERS

- Connector: M12 aviation plug 5P connector
- Protection level: IP67
- Shell material: frosted aluminum alloy
- Installation: Four M4 screws



• WORKING PRINCIPLE

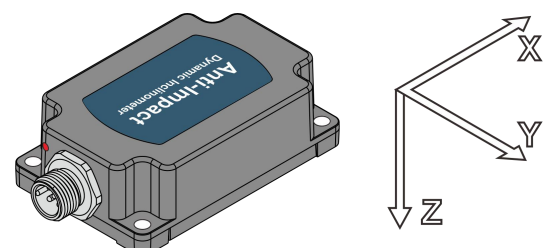
Adopt imported core control unit and apply the principle of capacitive miniature pendulum. Using the earth's gravity principle, when the tilt unit tilts, the earth's gravity will produce a gravitational component on the corresponding pendulum, and the corresponding capacitance will change. By amplifying and filtering the capacitance, the inclination will be obtained after conversion.



U_R , U_L are the voltage between the left and right pole plates of the pendulum and their corresponding electrodes, when the tilt sensor is tilted, U_R , U_L will change according to a certain rule, so $f(U_R, U_L)$ is a function on α of tilt angle: $\alpha = f(U_R, U_L)$.

• INSTALLATION AXIS DIRECTION

HDA446T follows the NED coordinate system, right-handed. According to the rotation sequence of ZYX, when the positive direction of the X axis is directed to the front of the carrier, the rotation angle around the Z axis is the heading angle, the rotation angle around the Y axis is the pitch angle, and the rotation angle around the X axis is the roll angle.



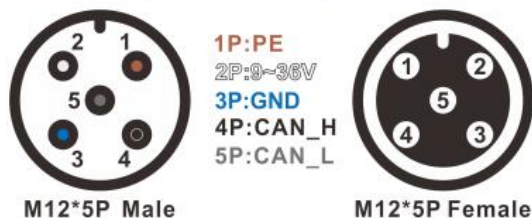
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• ELECTRICAL CONNECTION

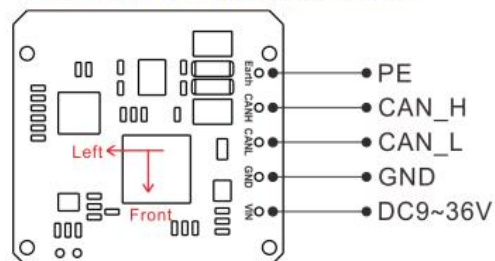
Definition of male wiring

PIN DEFINITION	1 Pin(Brown)	2 Pin(White)	3 Pin(Blue)	4 Pin(Black)	5 Pin(Gray)
	PE	9~36V Power supply positive	GND Power supply Negative	CAN_H	CAN_L

Connector pin definition diagram



PCBA board wiring definition diagram

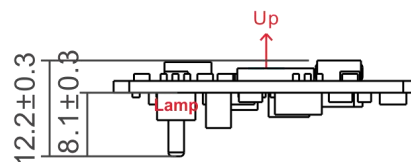
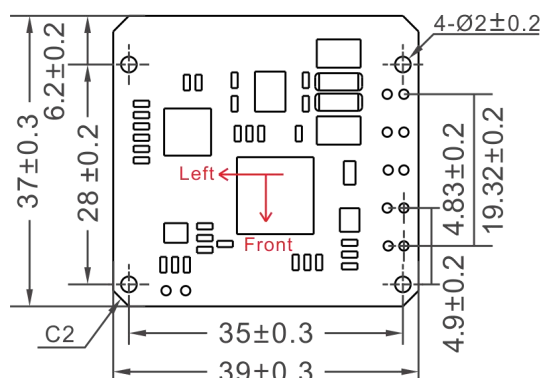


• WORKING INDICATOR LIGHT DESCRIPTION

1. The working indicator light flashes after the product is powered on;
2. The working indicator light is on when the product has data to send.

• SIZE

PCBA board dimensional drawing



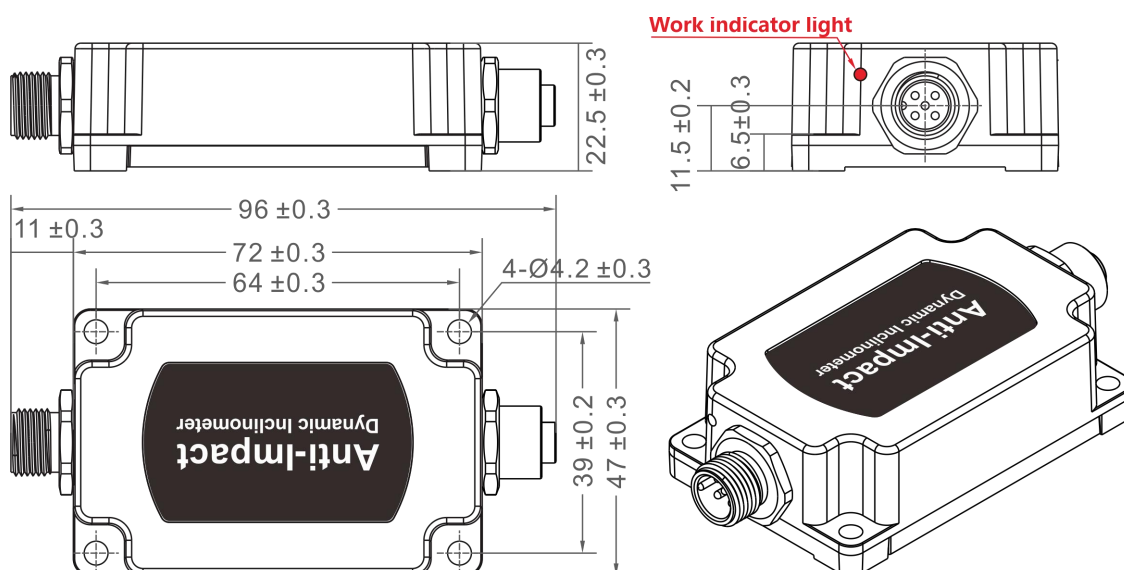
PCBA board size: L39×W37×H12.2mm

Installation size: 35 × 28mm

Mounting screws: 4 M2 screws

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Shell size of double connector



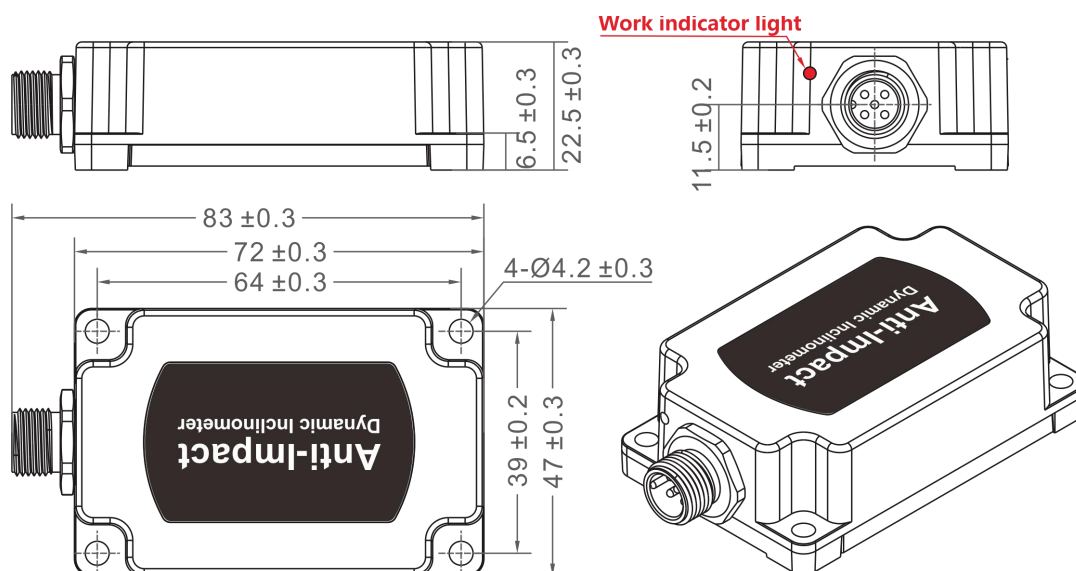
Shell size: $96 \times 47 \times 22.5$ mm

Installation size: $64 \times 39 \times 6.5$ mm

Mounting screws: 4 M4 screws

Shell material: aluminum alloy

Size of single connector



Shell size: $83 \times 47 \times 22.5$ mm

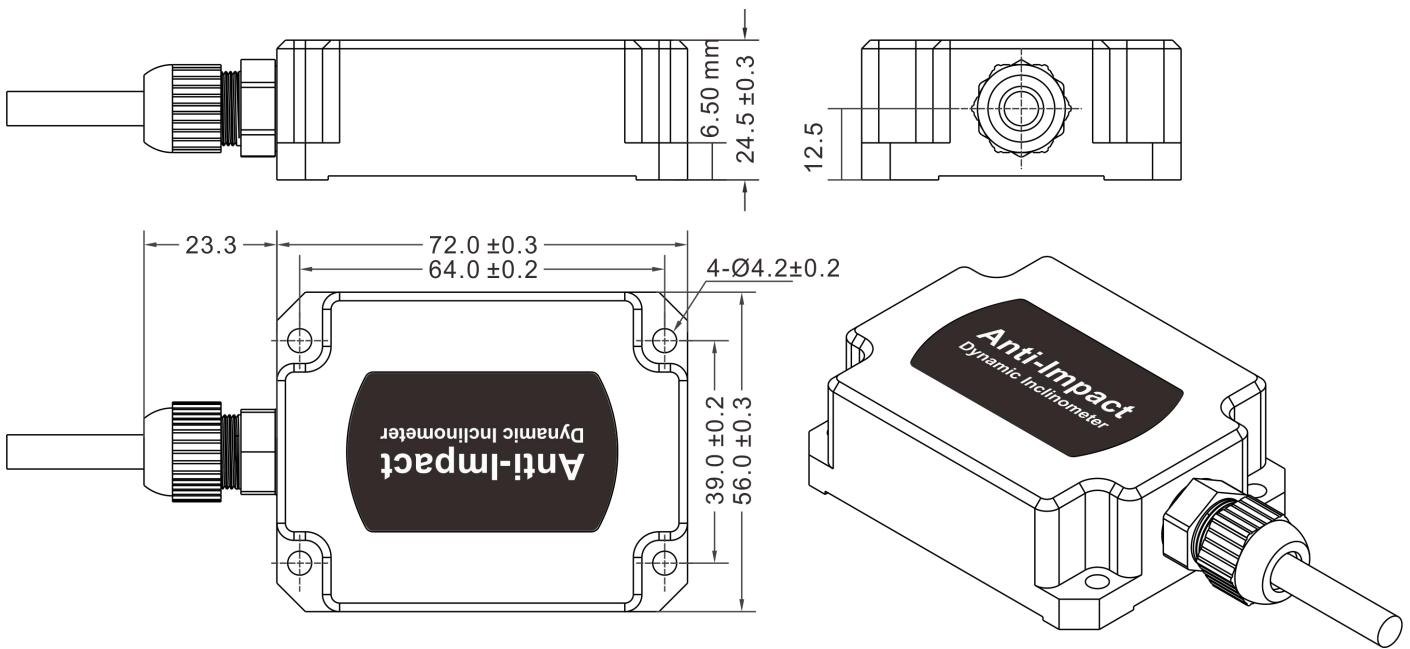
Installation size: $64 \times 39 \times 6.5$ mm

Mounting screws: 4 M4 screws

Shell material: aluminum alloy

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Size of corrosion-resistant IP68 protection direct outlet product



Shell size: 72 × 56 × 24.5mm

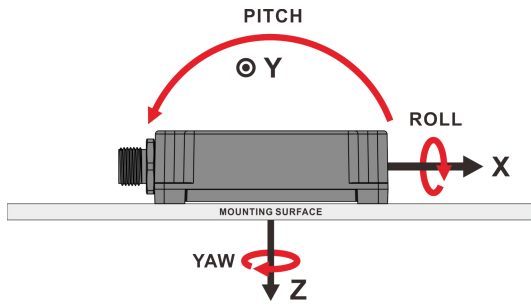
Installation size: 64 × 39 × 6.5mm

Mounting screws: 4 M4 screws

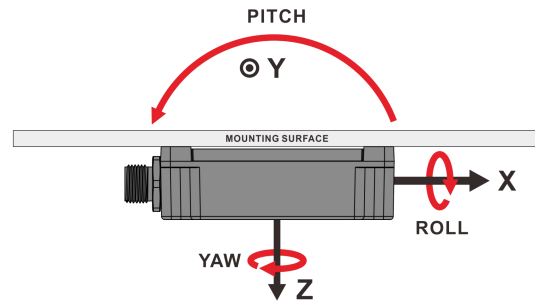
Shell material: 304 alloy steel

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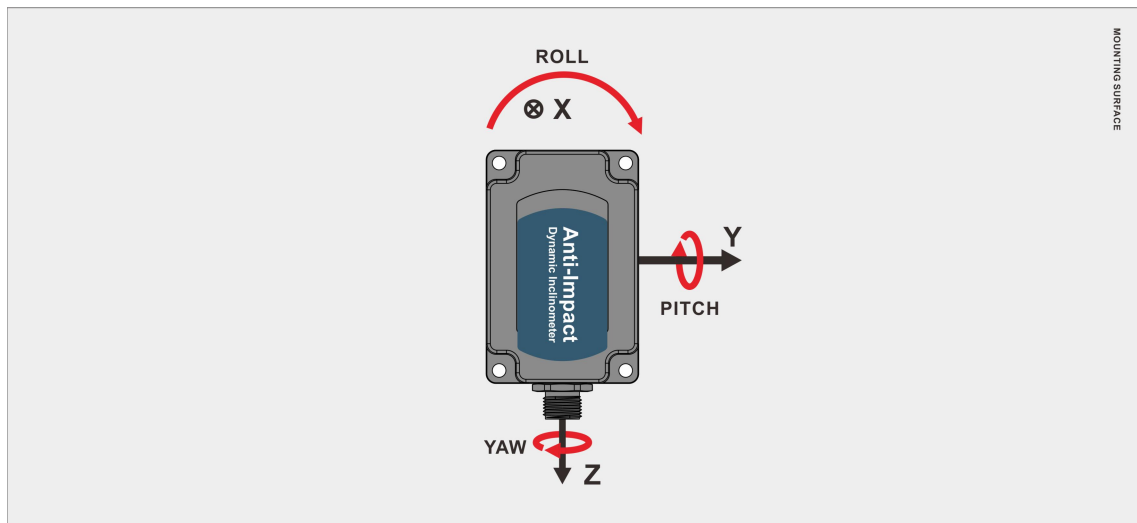
• INSTALLATION METHOD



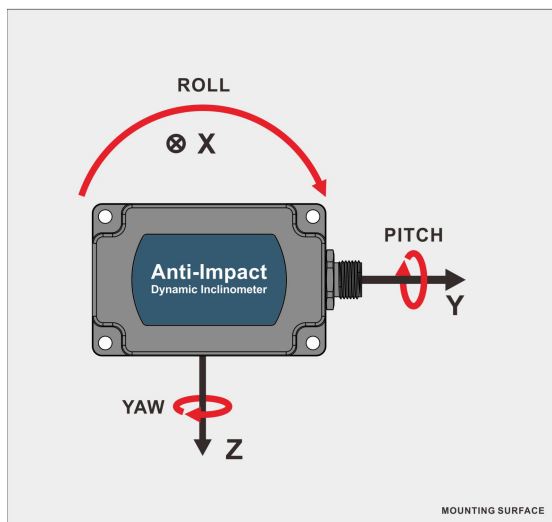
Horizontal Installation



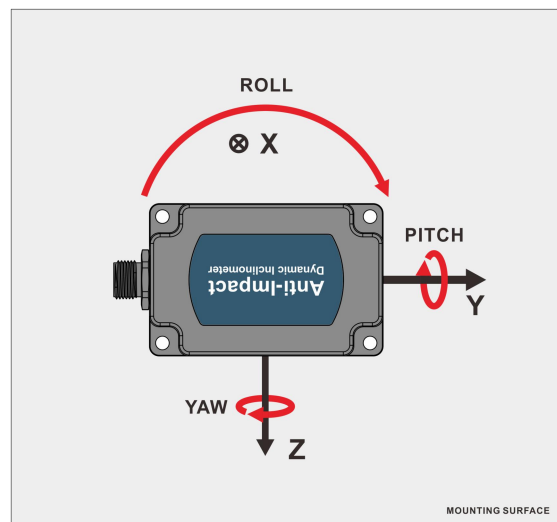
Horizontal-Down Installation



Vertical Installation



Vertical-Left Installation



Vertical-Right Installation

● COMMUNICATION FRAME FORMAT

CAN2.0 Protocol support 2.0A(11bit ID)and 2.0B(29 bit ID)

1) Modify the node number. (node range: 0x01-0x7F), the default node number is 0x05

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x600+0x05	0x40	0x10	0x10	0x00	Node_ID	0x00	0x00	0x00

Table1-3 request message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+0x05	0x40	0x10	0x10	0x00	Node_ID	0x00	0x00	0x00

Table1-4 response message format

Remark: if controller sends CAN-ID=0x600+0x05,sent data:40 10 10 00 10 00 00 00

sensor returns CAN-ID=0x580+0x05,returned data:40 10 10 00 10 00 00 00

received frame after restarting ID is 0x590(0x580+0x10), the data represents successful modification of frame ID.

2) CAN baud rate setting

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x600+0x05	0x40	0x20	0x10	0x00	Baud	0x00	0x00	0x00

Table1-5 request message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+0x05	0x40	0x20	0x10	0x00	Baud	0x00	0x00	0x00

Table1-6 response message format

remark: Fifth byte(Baud) is 0x01 / 0x02 / 0x03 / 0x04. In which 0x00 represent baud rate to be 1000K bps,0x01 represent baud rate to be 500K bps,0x02 represent baud rate to be 250K bps,0x03 represent baud rate to be 125K bps,0x04 represent baud rate to be 100K bps,default baud rate is 125K bps. Send above direct, restart power-on the sensor after receiving returned data, then modification of baud rate is finished.

3) Set automatic output cycle time (factory default output cycle 100mS)

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x600+0x05	0x22	0x00	0x22	0x00	T_L	T_H	0x00	0x00

Table1-5 request message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+0x05	0x22	0x00	0x22	0x00	T_L	T_H	0x00	0x00

The fifth and sixth bytes represent time, the fifth byte is the low byte, and the sixth byte is the high byte. The time range 10ms~1000ms;

Eg:10ms TIME_L=0x0A,TIME_H=0x00;

100ms TIME_L=0x64,TIME_H=0x00;

1000ms TIME_L=0xE8,TIME_H=0x03;

Range set 10ms~1000ms, The factory default value 100ms.

4) Set output frame type (factory default output angle frame)

Request message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x600+0x05	0x40	0x30	0x10	0x00	MASK	0x00	0x00	0x00

Reply message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+0x05	0x40	0x30	0x10	0x00	MASK	0x00	0x00	0x00

The lower 3 bits of the fifth byte Mask are valid. Mask (binary: 0B00000cba).

a: indicates the angle frame, 1: turn on the output, 0: turn off the output.

b: Represents the acceleration frame, 1: turn on the output, 0: turn off the output.

c: Represents the gyro angular velocity frame, 1: turn on the output, 0: turn off the output.

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The host sends: 40 30 10 00 07 00 00 00, the angle frame, acceleration frame and gyro angular velocity frame output will be turned on.

The host sends: 40 30 10 00 05 00 00 00, will turn on the angle frame and gyro angular velocity frame output, and turn off the acceleration frame output.

5) Azimuth clear zero

Request message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x600+0x05	0x40	0x10	0x10	0x00	0x10	0x10	0x10	0x10

Reply message format

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+0x05	0x40	0x10	0x10	0x00	0x10	0x10	0x10	0x10

Clear the current azimuth angle to zero.

6) Data analysis

1. Data frame types are divided into three types: angle frames, acceleration frames, and gyro frames.

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	Data0	Data1	Data2	Data3	Data4	Data5	Data6	flag

Data0-Data6: Represents data, and determines whether the data is angle, acceleration, or gyro frame according to the corresponding flag bit.

Flag(ddddccaa): Unsigned single byte, 8bit indicates the data frame type and installation measurement method:

aa: Represent data type of the frame

00: Represent the frame(roll angle $\pm 180^\circ$, pitch $\pm 90^\circ$, heading $\pm 180^\circ$);

01: represent acceleration($\pm 32.765g$);

10: represent gyro($\pm 327.65^\circ/S$);

cc: Indicates the result of power-on self-test:

00: Self-test is successful;

01: acceleration self-test fails;

10: Gyro BIT fails;

11: Both acceleration and gyro BIT fail;

dddd: Represents the installation test method (for specific reference to the measurement installation method illustration):

0000: horizontal installation measurement mode.

0001: vertical upward mounting measurement mode.

0010: vertical left (side to left) installation measurement method.

0011: vertical right (side to the right) installation measurement method.

0100: Indicates the horizontal downward installation measurement method.

The following is a data type frame analysis with different horizontal measurement methods:

A: Angle data frame

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	Temp	0x00

There are eight bytes of data behind CAN-ID. The first two bytes are XL, XH is the inclination of the X axis (ROLL roll angle), the third and fourth bytes are YL, and YH is the Y axis (PITCH pitch angle). The inclination angle is the fifth and sixth bytes ZL, and ZH is the inclination angle of the Z axis (YAW azimuth); the angle is int16_t, the low byte is first, the high byte is last, finally divided by 100 to get the angle floating point number.. The 7th byte is the temperature value, which is a signed single byte integer.

Example of angle conversion:

26 15 DA EA 28 23 19 00

Flag = 0x00, indicating the horizontal installation measurement method, the data is the angle.

The angle data size of the X-axis roll angle is represented by a 16-bit signed binary number, the upper 8 bits are XH, and the lower 8 bits are XL.

This 16-bit signed binary number is converted to a decimal number and then divided by 100.

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The result is the angle. Eg, XL=0x26, XH=0x15, angle is 54.14°

XH XL

0x15 0x26

0x1526(5414)

Final result:5414/100=54.14°

YH YL

0xEA 0xDA

0xEADA(-5414)

Final result:-5414/100=-54.14°

ZH ZL

0x23 0x28

0x2328(9000)

Final result:9000/100=90.00°

Temp

0x19(25) = 25° Celsius.

B: Acceleration data frame

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	0x00	0x01

There are eight bytes of data behind CAN-ID. The first two bytes are XL, XH is the X-axis acceleration, the third and fourth bytes are YL, YH is the Y-axis acceleration, and the fifth and sixth bytes ZL and ZH are the acceleration of the Z axis; the acceleration is int16_t, the low byte is first, the high byte is last, and then divide by 1000 to get the acceleration floating point number. The seventh byte is reserved.

Example of acceleration conversion:

26 15 DA EA 28 23 19 01

Flag=0x01, which indicates the horizontal installation measurement method, and the data is acceleration.

The X-axis acceleration data size is represented by a 16-bit signed binary number, the upper 8 bits are XH, and the lower 8 bits are XL.

This 16-bit signed binary number is converted to a decimal number, and then divided by 1000. The result is the acceleration.

Eg:XL=0x26 / XH=0x15 / Acceleration is 5.414g

XH XL

0x15 0x26

0x1526(5414)

Final result:5414/1000=5.414g

YH YL

0xEA 0xDA

0xEADA(-5414)

Final result:-5414/1000=-5.414g

ZH ZL

0x23 0x28

0x2328(9000)

Final result:9000/1000=9.000g

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C: Gyro data frame

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	0x00	0x02

There are eight bytes of data behind **CAN-ID**. The first two bytes are XL, XH is the size of the X-axis gyro, the third and fourth bytes are YL, YH is the size of the Y-axis gyro, and the fifth and sixth bytes ZL, ZH is the size of the Z-axis gyroscope; the size of the gyroscope is int16_t, with the low byte first and the high byte last.

Finally divide by 100 to get the gyro floating point number. The seventh byte is reserved.

Example of acceleration conversion:

26 15 DA EA 28 23 19 02

Flag = 0x02, indicating the horizontal installation measurement method, the data is a gyro.

The X-axis gyro data size is represented by a 16-bit signed binary number, the upper 8 bits are XH, and the lower 8 bits are XL.

This 16-bit signed binary number is converted to a decimal number and then divided by 100.

The result is the gyro value.

For example, XL = 0x26, XH = 0x15, the gyro value is 54.14°/S

XH XL

0x15 0x26

0x1526(5414)

Final result: 5414/100=54.14°/S

YH YL

0xEA 0xDA

0xEADA(-5414)

Final result: -5414/100=-54.14°/S

ZH ZL

0x23 0x28

0x2328(9000)

Final result: 9000/100=90.00°/S

2. There are three ways of data period output: single frame angle output (period one angle frame output, the default output mode), double frame angle plus indication output (double frame, continuous output double frames by period), three frame angle gyro plus indication Output (three frames, three frames are output continuously by cycle). Can be set at the factory.

A.Single-frame angle output (periodically output one angle frame, the default output mode), the message format is as follows:

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	Temp	0x00

B.The angle plus indication of double frames is output (double frames, double frames are output continuously by cycle). The message format is as follows:

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	Temp	0x00

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CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	0x00	0x01

C.Three frames of angle gyro plus representative output (three frames, three frames are output continuously by cycle), the message format is as follows:

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	Temp	0x00

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	0x00	0x01

CAN-ID	1 st byte	2 nd byte	3 rd byte	4 th byte	5 th byte	6 th byte	7 th byte	8 th byte
0x580+Node_ID	XL	XH	YL	YH	ZL	ZH	0x00	0x02