



# **BW-AH225Serials**

## **Low cost CAN bus AHRS**

### **Technical Manual**



## Introduction

BW-AH225 Attitude and Heading Reference System (AHRS) is a high performance, low cost inertial measurement device that measures the attitude parameters (roll and pitch), angular velocity, acceleration information and heading angle of the dynamic carrier. The attitude and angular velocity deviations are estimated by a 6-state Kalman filter with appropriate gain, which is suitable for dynamic measurement of navigation and positioning. The BW-AH225 uses high-quality and reliable MEMS accelerometers, gyroscopes and magnetometers, and guarantees measurement accuracy through algorithms. Meanwhile, the seal design and strict process ensure that the dynamic parameters of the carrier such as the angular velocity, acceleration and attitude can be accurately measured under harsh conditions. Through various compensations such as nonlinear compensation, quadrature compensation, temperature compensation and drift compensation, the error source of BW-AH225 can be greatly eliminated, and the product accuracy level can be improved. The BW-AH225 is equipped with digital interface that can be easily integrated into the user's system.

## Feature

- Nonlinear compensation, quadrature compensation
- Dynamic static measurement
- Special offset tracking algorithm eliminates drift
- Gyro drift compensation
- Heading accuracy 1°
- CAN bus output
- temperature range: -40°C~+85°C, temperature compensation technical
- High performance Kalman filter algorithm
- Product size: L60 x W59 x H29 (mm)

## Application

- Satellite tracking
- High voltage tower monitoring
- Aerial work vehicle
- ROV underwater robot navigation
- Drilling equipment measurement and control
- Ocean Tester
- Robot control
- Unmanned aerial vehicle

## Introduction

### Electrical Specifications

Voltage	9-35V DC
Working current	30mA (40mA max)
Operating temperature	-40~85°C
Storage temperature	-55~100°C

### Performance Specifications

Attitude parameters	Pitch Accuracy	1° (RMS, dynamic) 0.1° (RMS, Static)
	Roll accuracy	1° (RMS, dynamic) 0.1° (RMS, Static)
	Resolution	0.01°
	Slant Range	Pitch ± 90°, Roll ± 180°
Heading parameters	Heading Accuracy	1° (Pitch<40°)
		1.2° (Pitch<60°)
		1.5° (Pitch<80°)
	Resolution	0.01°
Physical characteristics	Size	L60 x W59 x H29 (mm)
	Weight	150g
	Output form	CAN
Interface characteristics	Start Delay	<3s
	Maximum Output Rate	50Hz
	Serial Communication Rate	2400-115200 Baud rate
	Digital Output Format	Binary high performance protocol
Environment	Vibration Resistance	2000g

**Resolution:** The smallest change in the value that the sensor can detect and resolve within the measurement range.

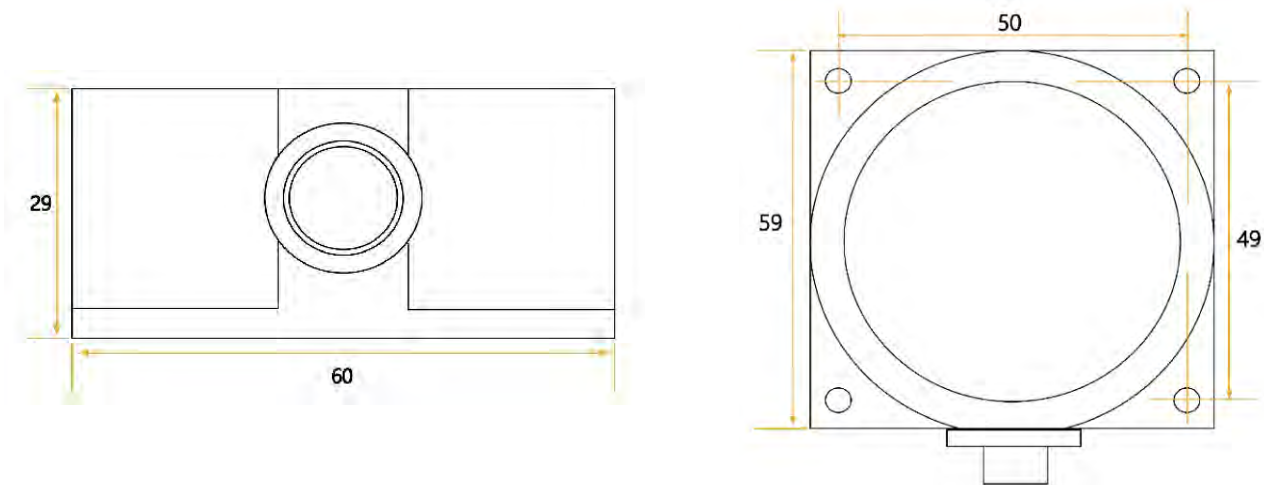
**Accuracy:** The root mean square error of the actual angle and the measured angle of the sensor multiple times (≥16 times).

 Mechanical Characteristic

Connector	Metal joint (Line length 1.5m)
Protection level	IP67
Shell material	Magnesium alloy oxidation
Installation	Four M4 screws

 Package size

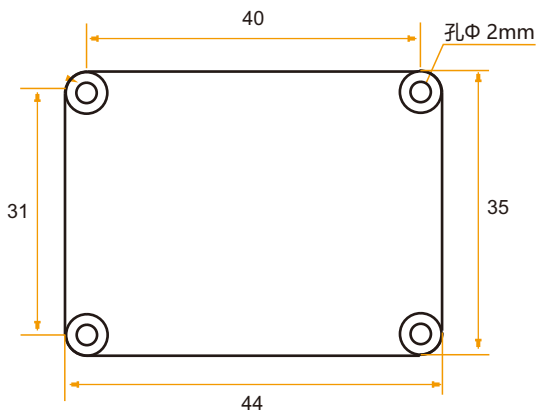
Size: L60\*W59\*H29 (mm)



 Bare plate product size

Size: L44\*W35\*H11 (mm)

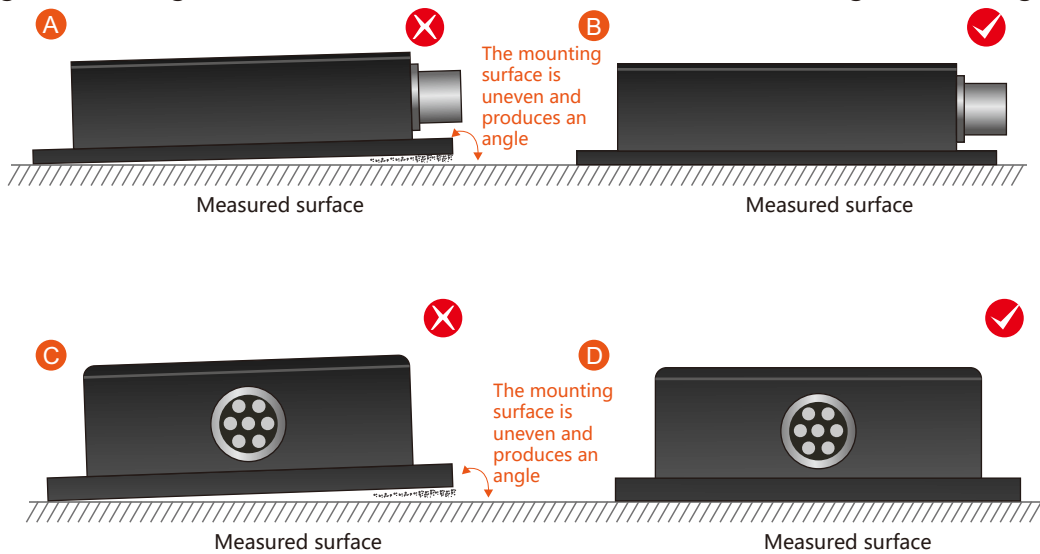
Note: ±1mm error for length and width dimensions, please refer to actual size.



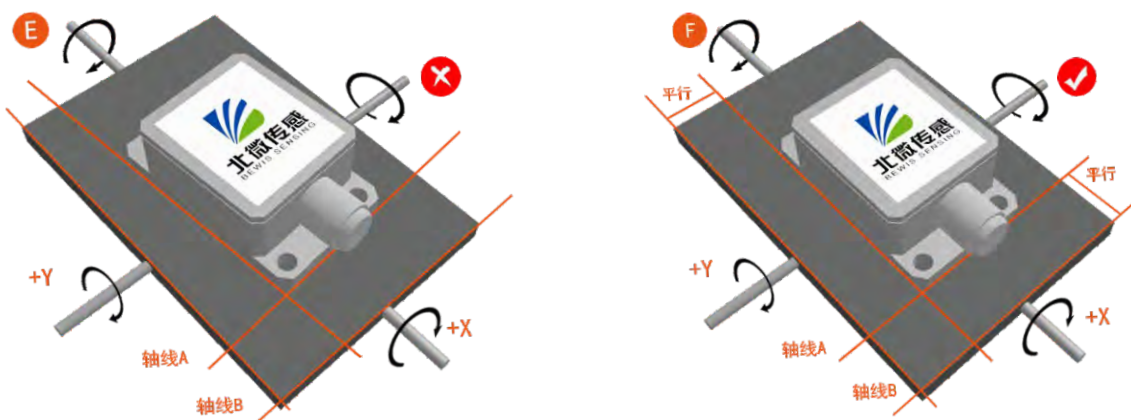
## Product installation

The correct installation method can avoid measurement errors, and the following points should be taken when installing the sensor:

First of all, to ensure that the sensor mounting surface is completely close to the measured surface, the measured surface should be as horizontal as possible, and there should be no angle shown in Figure A and Figure C. The correct installation method is shown in Figure B and Figure D.



Secondly, the bottom edge of the sensor and the axis of the object to be measured cannot be generated at an angle as shown in Figure E. The bottom edge of the sensor should be kept parallel or orthogonal to the axis of rotation of the object to be measured. This product can be installed horizontally or vertically (vertical installation requires customization), and the correct installation method is shown in Figure F.



Finally, the mounting surface of the sensor and the surface to be measured must be fixed, the contact is flat, and the rotation is stable. The measurement error caused by acceleration and vibration should be avoided.

## Measurement installation

The azimuth reference system has been calibrated at the factory. In places where the influence of the magnetic field environment is small, it is not necessary to perform environmental calibration when using it, and it can be used directly. During actual use, it is recommended to perform calibration.

Azimuth calibration steps:

Method 1 - Plane calibration:

1. Connect the product to the system and place the product in a horizontal state;
2. Open the CAN debugging tool and send 605 40 11 10 00 00 00 00 00;
3. Rotate the product in the horizontal plane (with the pitch and roll angles within  $\pm 5^\circ$ ) around the z-axis (the z-axis is vertical) and rotate 2-3 turns, the rotation process is as slow as possible and rotates at a constant speed. The time of one rotation is controlled between 10 seconds and 15 seconds.
4. Rotate the compass around the x-axis or y-axis. The rotation can be performed at a slow speed and near-uniform rotation. Rotate 2-3 turns around each axis for a period of about 15 seconds.
5. Complete the calibration and send 605 40 12 10 00 00 00 00 00 to save the calibration.

Method 2 - Multi-faceted calibration:

1. Fix the electronic compass in the use environment, and try not to carry magnetic items such as keys and mobile phones during calibration;
2. Place the compass in a horizontal state (within  $\pm 5$  degrees);
3. Send the following calibration command in hexadecimal format: 605 40 08 10 00 00 00 00 00;
4. The product is placed horizontally, face up (pitch and roll are within  $0 \pm 5$  degrees), myopia rotates at a uniform speed for one week, and rotation takes more than ten seconds.
5. The product is placed horizontally with the mounting surface facing up (within  $0 \pm 5$  degrees of pitch and  $180 \pm 5$  degrees of rolling). The myopia rotates at a uniform speed for one week, and it takes about 10 seconds to rotate one week.
6. The product is placed in a vertical state with the smooth side of the casing facing down (within  $0 \pm 5$  degrees of pitch and  $90 \pm 5$  degrees of rolling). The myopia rotates at a uniform speed for one week, and it takes about 10 seconds to rotate one week.
7. The product is placed in a vertical position, and the other smooth side of the casing faces downward (within  $0 \pm 5$  degrees of pitch and within  $-90 \pm 5$  degrees of rolling). The approximately rotates at a uniform speed for one week, and it takes about 10 seconds to rotate one week;

Where 4.5.6.7 steps can be exchanged;

8. After the four faces have been rotated, send the hexadecimal command 605 40 09 10 00 00 00 00 00 to save the calibration and return to 585 40 09 10 00 XX 00 00 00. Where XX represents the calibration error coefficient, the smaller the value, the better, less than 10 is ideal, and FF indicates calibration failure;

9. Calibration is complete.

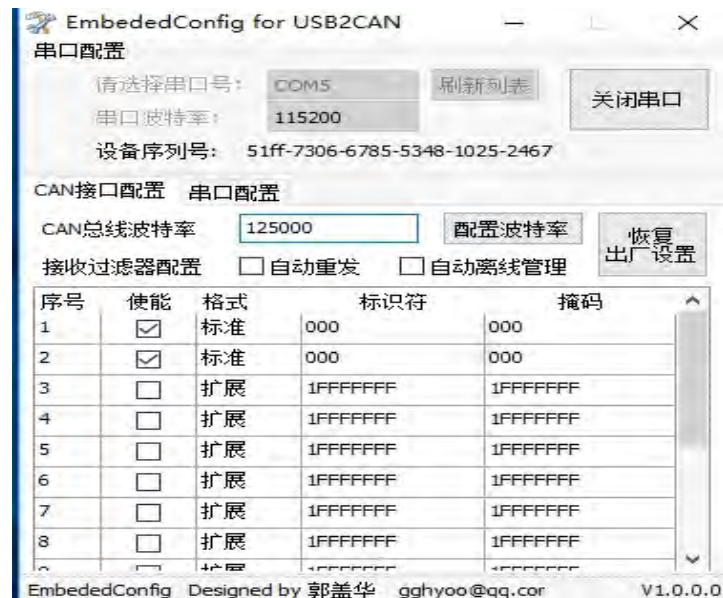
Clear calibration data command: 605 40 13 10 00 00 00 00 00

## Debugging software

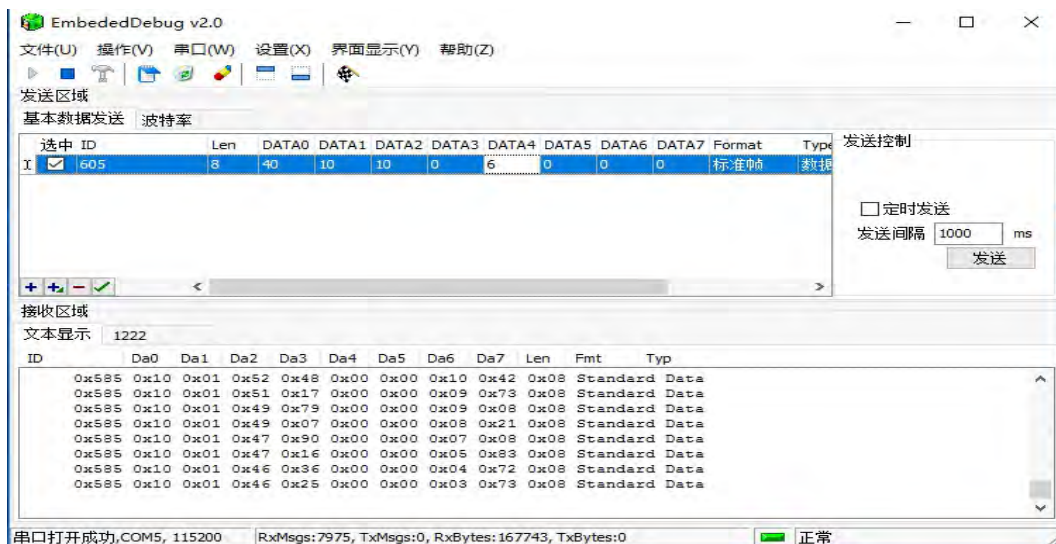
Since there is a dedicated CAN receiving device for data communication with CAN interface products, the software is a CAN acquisition device. The software used is not the same, so there is no corresponding software. Let's take the CAN receiver module and product communication adopted by our company as an example:



Configure the CAN baud rate and parameters as follows:



The receiving and sending areas are set as follows:



## Protocol

The CAN includes 8 bytes, and the data byte is not enough to be followed by 0. Sending the first byte 0x40 indicates a write command, and returning the first byte 0x40 indicates that the write was successful. The ID is the CAN communication node number. Default: CAN baud rate is 125K, 100HZ auto output, node number is 05.

### 1) Modify the node number:

(ID=0x01 ~ 0x7F) , The default node number (ID) is 0x05

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x10	0x10	0x00	ID	0x00	0x00	0x00
answer	0x580+0xID	0x40	0x10	0x10	0x00	ID	0x00	0x00	0x00

Note: The default node number is 05 and the ID indicates the node number to be modified.

For example, if the node number is changed to 08, you need to send 605 40 10 10 00 08 00 00 00.

The return value is 588 40 10 10 00 08 00 00 00, indicating that the node has been modified to 08.

At this time, when sending other naming, you need to change the CAN-ID to 0x608 to send successfully.

There is no need to send a save command.

### 2) Set the CAN baud rate:

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x20	0x10	0x00	Baud	0x00	0x00	0x00
answer									

Note: The fifth byte (Baud) is 0x01, 0x02, 0x03, 0x04, 0x05, 0x06. 0x01 represents the setting baud rate of 500K bps,

0x02 represents the set baud rate of 250K bps,

0x03 represents the set baud rate of 125K bps,

0x04 represents the set baud rate of 100K bps,

0x05 represents the set baud rate of 50K bps,

0x06 represents the set baud rate of 25K bps,

The default baud rate is 125K bps. After modifying the baud rate, the sensor needs to be powered on again, and the baud rate modification can be successful.

### 3) Set relative \ absolute zero:

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x05	0x10	0x00	Type	0x00	0x00	0x00
answer	0x580+0x05	0x40	0x05	0x10	0x00	0x00	0x00	0x00	0x00

Note: The 5th byte Type is 0x00, 0x01. 0x00 means to set to absolute zero, 0x01 means the pitch and roll angle are set to relative zero, 0x02 means the azimuth is set to relative zero, after setting the zero point, you need to enter the save command. Can be set successfully. (Default is absolute zero)

Absolute zero: The measurement angle is based on the factory-calibrated zero point.

Relative zero: The measurement angle is zero reference to the current position.



#### 4) Query relative\absolute zero:

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x0d	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	0x40	0x05	0x10	0x00	Type	0x00	0x00	0x00

Note: The 5th byte Type is 0x00, 0x01. 0x00 is represented as absolute zero, and 0x01 is represented as relative zero.

#### 5) save

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x0a	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	0x40	0x0a	0x10	0x00	0x00	0x00	0x00	0x00

Note: After some parameters are modified, you need to send a save command to take effect.

#### 6) Read each attitude angle

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x04	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	SX	XX	xx	SX	YY	yy	BB	Bb

Note: The read angle command needs to be valid in the answer mode.

The pitch angle is represented by a 3-byte BCD code (1~3 bytes). The highest bit S is a sign bit, 0-positive; 1-negative, uppercase X is an integer bit, lowercase x is a decimal place; roll angle is 3 The BCD code of the byte indicates (4~6 bytes) that the highest bit S is a sign bit, 0-positive; 1-negative, uppercase Y is an integer bit, lowercase y is a decimal place; azimuth is 2 bytes BCD The code indicates (7~8 bytes) unsigned bits, uppercase B is an integer bit, and lowercase b is a decimal place;

For example, if the returned data is 585 00 12 34 10 12 34 26 35, it means that the pitch angle is +12.34 degrees, the roll angle is -12.34 degrees, and the azimuth angle is 263.5 degrees.

#### 7) Set output mode

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x0c	0x10	0x00	mode	0x00	0x00	0x00
answer	0x580+0x05	0x40	0x0c	0x10	0x00	mode	0x00	0x00	0x00

Note: The fifth byte mode is 0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06. Where 0x00 represents the answer mode,

0x01: 5Hz Data Rate, 0x02: 10Hz Data Rate,  
 0x03: 20Hz Data Rate, 0x04: 25Hz Data Rate,  
 0x05: 50Hz Data Rate, 0x06: 100Hz Data Rate (default) ,

5Hz Data Rate means 5 times of data is output automatically every second. Sending other names should be done in Q&A mode (automatic mode is to continuously output the current angle of the axis according to the specific frequency. In the answer mode, it is easier to see other commands return. value).

### 8) Reading angular velocity

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x50	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	0x50	0x00	AA	AA	BB	BB	CC	CC

Note: The angular velocity of the X axis is (AAAA5000)/10.

The angular velocity of the Y axis is (BBBB-5000)/10,

The angular velocity of the Z axis is (CCCC-5000)/10,

For example, when the received data is 585 50 00 50 12 50 07 50 11, the data on the X-axis is (5012-5000)/10 = 1.2°/s, and so on.

### 9) Read acceleration

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x54	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	0x54	0x00	AA	AA	BB	BB	CC	CC

Note: The X-axis acceleration is (AAAA-5000)/2500.

The y-axis acceleration is (BBBB-5000)/2500,

The Z-axis acceleration is (CCCC-5000)/2500,

For example, when the received data is 585 54 00 51 05 49 72 25 79,

The data for the X-axis is (5105-5000)/2500 = 0.042g, where g is the Earth's gravitational acceleration.

### 10) Reading magnetic field value

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x55	0x10	0x00	0x00	0x00	0x00	0x00
answer	0x580+0x05	0x55	0x00	AA	AA	BB	BB	CC	CC

Note: The X-axis magnetic field value is (AAAA-5000)/5000.

The Y-axis magnetic field value is (BBBB-5000)/5000.

The Z-axis magnetic field value is (CCCC-5000)/5000.

For example, when the received data is 585 55 00 64 85 35 07 50 16, the data on the X-axis is (6485-5000)/5000=0.297G, and G is Gaussian.

### 11) Select automatic output data

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x53	0x10	0x00	mode	0x00	0x00	0x00
answer	0x580+0x05	0x40	0x53	0x10	0x00	mode	0x00	0x00	0x00

Note: The data of the mode bit output is selected, where 0x00: automatic output attitude angle (default)  
 0x01: Automatic output acceleration  
 0x02: Automatic output angular velocity  
 0x03: Automatic output magnetic field value  
 0x04: Automatic output attitude angle, acceleration, angular velocity  
 0x05: automatic output attitude angle, acceleration, angular velocity, magnetic field value

### 12) Set the magnetic declination

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x06	0x10	0x00	SY	Yy	0x00	0x00
answer	0xXHXL+0x05								

Note: The magnetic declination is represented by a 2-byte BCD code (5~6 bytes). The highest bit S is a sign bit, 0-positive; 1-negative, uppercase Y is an integer bit, and lowercase y is a decimal place.

### 13) Set the standard CAN-ID address

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x70	0x10	0x00	XX	0x00	0x00	0x00
answer									

Note: XX is 00, 01.00 represents the standard ID (11-bit) type, and 01 represents the extended ID (27-bit) type. The default is standard.

### 14) Set the standard CAN-ID address

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x71	0x10	0x00	XH	XL	0x00	0x00
answer	0xXHXL+0x05								

Note: The standard CAN-ID defaults to 0X580+05 and the maximum value cannot exceed 7FF. The modification here is that 580,05 in 0X580+05 can be modified by modifying the node number in the previous section. After powering up, the CAN-ID will become 0x XHXL+0x05.

For example, if you send data: 605 40 71 10 00 01 23 00 00, the CAN-ID becomes 123+5=128 after power-off then power-on.

### 15) Set the extended CAN-ID address

When setting the extended CAN-ID address, you need to split the address into two segments, first sending a high 16 address, and then lowering the 16-bit address. Re-power on CAN-ID

It becomes the changed address (the CAN-ID received here does not need to add the node number). The maximum value cannot exceed 7FFFFFFF. The default is 0x 18fa0216.

### I Set the extended CAN-ID high 16-bit address

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x72	0x10	0x00	XH	XL	0x00	0x00
answer									

Note: The extended CAN-ID high 16-bit address cannot be greater than 7FF.

### II Set the extended CAN-ID low 16-bit address

	CAN-ID	First byte	Second byte	Third byte	Fourth byte	Fifth byte	Sixth byte	Seventh byte	Eighth byte
send	0x600+0x05	0x40	0x73	0x10	0x00	XH	XL	0x00	0x00
answer									

Note: The extended CAN-ID low 16-bit address cannot be greater than FFFF.

For example, if you send 605 40 72 10 00 01 23 00 00, 605 40 73 10 00 45 67 00 00 twice, the CAN-ID will be 01234567 after power-off.

## Ordering Information

Product number	Product number	Package condition
BW-AH225-CAN	CAN	IP67 package / metal connector

## Executive standard

- Enterprise Quality System Standard: ISO9001:2008 Standard (Certificate No.:10114Q16846ROS)
- CE certification (certificate number: 3854210814)
- ROHS (certificate number: SO81426003)
- GB/T 191 SJ 20873-2003 General specifications for tiltmeters and spirit levels
- GBT 18459-2001 sensor main static performance index calculation method
- JF 1059-1999 Evaluation and Expression of Measurement Uncertainty
- GBT 14412-2005 mechanical vibration and shock mechanical installation of accelerometer
- General requirements for GJB 450A-2004 equipment reliability
- Quality control of key parts and important parts of GJB 909A
- GJB 899 Reliability Qualification and Acceptance Test
- GJB 150-3A high temperature test
- GJB 150-4A low temperature test
- GJB 150-8A rain test
- GJB 150-12A dust test
- GJB 150-16A vibration test
- GJB 150-18A impact test
- GJB 150-23A Tilt and Swing Test
- GB/T 17626-3A RF electromagnetic radiation immunity test
- GB/T 17626-5A surge (hit) impulse immunity test
- GB/T 17626-8A power frequency magnetic field immunity test
- GB/T 17626-11A voltage dips, short interruptions and voltage changes immunity

# BW-AH225

Low cost CAN bus AHRS

Wuxi Bewis Sensing Technology LLC  
Address: Building 30, No. 58 Xiuxi Road,  
Binhu District,  
Wuxi City  
Hotline: 400-618-0510  
Tel: +86 510 85737178-801  
Email: [sales@bwsensing.com](mailto:sales@bwsensing.com)  
Website: [www.bwsensing.com](http://www.bwsensing.com)