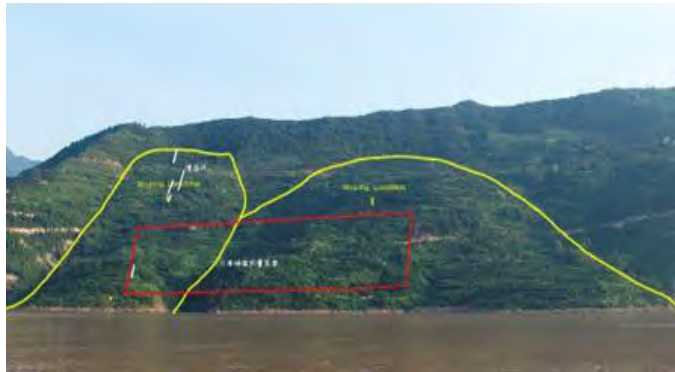


BWM400 数字双轴倾角计

Digital Dual-Axis Inclinometer
Technical Manual



Introduction

Designed by Bewis Sensing Technology LLC, BWM400 is a cost-effective digital dual-axis inclinometer which output mode is RS485 and TTL optional. It adopts the latest technology MEMS manufacturing process tilting unit, with small size, low power consumption, high consistency and stability. Because it is a digital inclinometer, the linearity is more easily corrected. The operating temperature reaches the industrial grade $-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$.

When multi-section cascading is used, we provide a multi-section slanting algorithm, which can accurately measure the displacement of large length and deep depth, and provides an automatic calibration algorithm.

Features

- Dual-axis inclination measurement
- Measuring range: $\pm 60^{\circ}$
- Accuracy: 0.005°
- Voltage input: 9~35V(DC)
- Output mode: RS485/TTL optional
- Multi-section cascade
- Operating temperature: $-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$
- High vibration resistance $>2000\text{g}$
- Resolution: 0.001°
- Volume: 1m cylindrical long measuring oblique section, diameter 28.1mm

Applications

- Foundation pit monitoring
- Soil monitoring
- Dam tailings monitoring
- Exploration well monitoring
- Slope monitoring
- High-speed rail monitoring
- Piling monitoring
- Deep displacement

Specifications

Electrical Specifications

Parameters	Conditions	Min	Typical	Max	Units
Power supply		9	12	35	V
Operating current	Non-loaded	20	30	40	mA
Operating temperature		-40	25	+85	°C
Store temperature		-55	25	+100	°C

Performance Specifications

Parameters	Conditions	BWM400-5	BWM400-30	BWM400-60	Units
Measuring range	Conditions	±5	±30	±60	°
Measuring axis		X-Y	X-Y	X-Y	
Accuracy	Indoor	0.005	0.01	0.05	°
Resolution		0.001	0.001	0.001	°
Zero temperature drift	-40~85°C	±0.001	±0.001	±0.001	°/°C
Cross axis error	25°C	0.005	0.01	0.05	°
Frequency response		100	100	100	Hz
MTBF	≥90000 hours/time				
Electromagnetic compatibility	according to GBT17626				
Insulation resistance	≥100 MΩ				
Shock resistance	2000g,0.5ms,3times/axis				

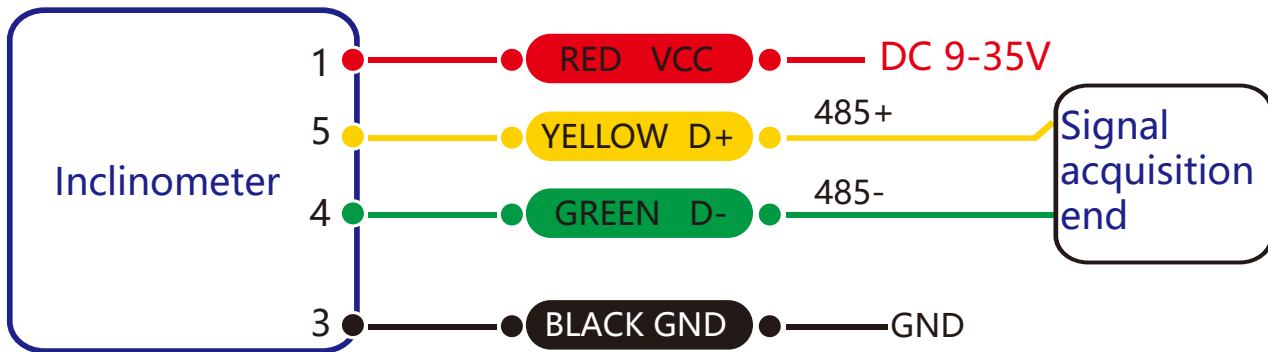
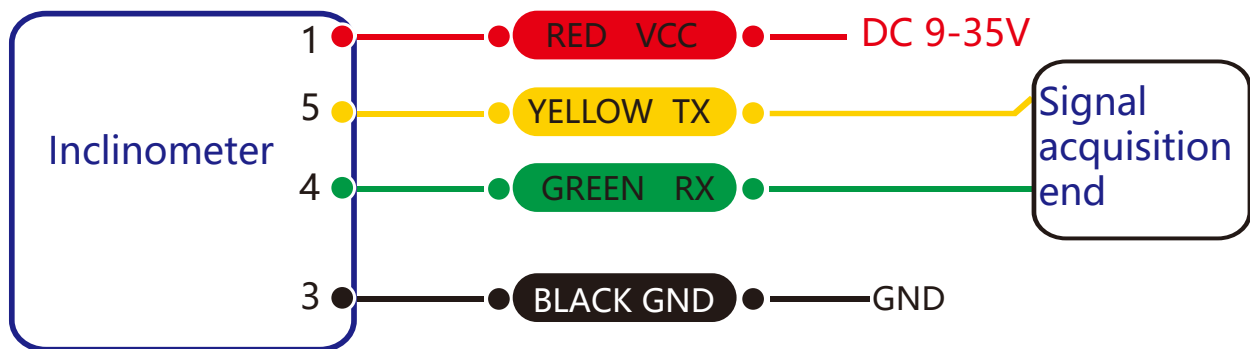
Resolution: The measured minimum change value that the sensor can detect and resolve within the measurement range.

Accuracy: The error between the actual angle and the Root mean square(RMS) of the measured angle of the sensor (≥16 times).

Electrical connections

Electrical interfaces

Cable color & Function	RED	BLUE	BLACK	GREEN	YELLOW
	1	2	3	4	5
VCC DC 9-35V	NC	GND	B 485-	A 485+	



Debug software

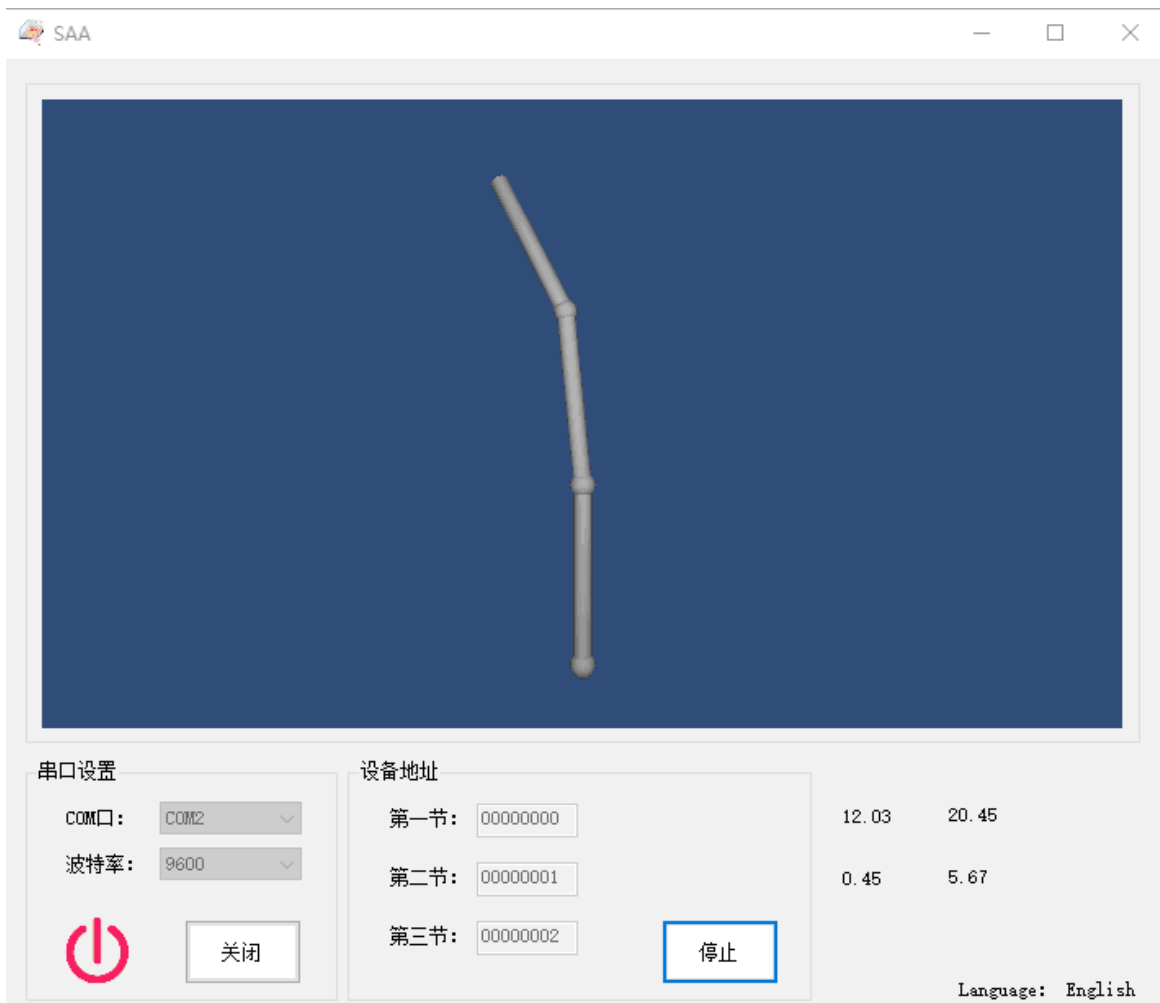
Users can directly download serial assistant on official website (Supports-Download). You can also use more convenient and intuitive PC software.

BWS4000 supporting serial debugging software can be connected to the inclinometer on the computer for angle display. The software debugging interface is as shown in the figure below. Using the debug software, it can conveniently display the current X-direction and Y-direction tilt angle, and you can also modify and set other parameters by yourself.

Software use steps:

- ① Correctly connect the inclinometer serial port hardware and connect the power supply.
- ② Select the computer serial port and baud rate and click connect Serial Port.
- ③ Click Start and the tilt angle of the tilter in the X direction and Y-direction will be displayed on the screen.

Note: You can switch to Chinese or English version by the bottom left button.



Protocol

1 Data Frame Format: (8 data bits, 1 stop bit, No parity check, default baud rate 9600)

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (Nbyte)	Checksum (1byte)
0x77					

Data Format: Hexadecimal(The following command interprets Table 0X as a hexadecimal identifier. You do not need to enter 0X, such as 0x77, you only need to enter 77.)

Identifier: Fixed to 77

Frame Length: Length from Frame Length to Checksum (included)

Address Code: Address of acquiring module, default 0x00

Data: Content and length variable according to Command

Checksum: Sum of Frame Length, Address Code, Command and Data. (Please pay attention that when the command or data changes, the checksum will change.)

2 Command Format

2.1 Read angle of X axis Command: 77 04 00 01 05

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77			0x01	-	

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (4byte)	Checksum (1byte)
0x77			0x81	SXXX.YYY0	

Note: The data field is a 4-byte return angle value, which is a compressed BCD code. S is the sign bit (0 means positive, 1 means negative), XXX is the three digit integer part, YYY is the fractional part. The Data of other axis is the same format. For example, 10 26 80 means -026.80 °.

2.2 Read angle of Y axis Command: 77 04 00 02 06

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77			0x02	-	

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (4byte)	Checksum (1byte)
0x77			0x82	SXXX.YYY0	

2.3 Read angle of X,Y axis Command: 77 04 00 04 08

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77			0x04		

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (12byte)	Checksum (1byte)
0x77			0x84		

Note: The data field is a 16-byte return angle value divided into three groups of four compressed BCD codes. They are the X-axis angle, the Y-axis angle, and the temperature. Each axis data format SXXX.YYY0, S is a sign bit (0 positive, 1 negative) XXX is a three-digit integer value, YYY is a three-digit decimal value. The other axis data is the same. For example, 10 26 87 60 means -026.8760°.

Such as: 77 13 00 00 00 00 84 10 09 15 50 00 07 54 10 00 23 08 40 EB

Where 10 09 15 50 represents the X-axis angle of -9.155°, and 00 07 54 10 represents the Y-axis angle of 7.541°.

2.4 Set absolute/relative zero point Command: 77 08 00 00 00 00 05 01 0E

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x05	0x00: absolute zero 0x01: relative zero	

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x85	0x00: success 0xFF: failure	

Note: absolute zero: Based on the factory-calibrated zero point.

relative zero: Reference to the zero after the current installation.

2.5 Query relative / absolute zero Command: 77 07 00 00 00 00 0D 14

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77			0x0D		

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x8D	0x00: absolute zero 0xFF: relative zero	

Note: This command refers to whether the zero point reference used in the current state is relative zero or absolute zero.

2.6 Set output mode Command: 77 08 00 00 00 00 0C 00 14

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x05		0x0C	0x00: question and 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	

Note: The default output mode is 00. When setting the 100Hz output frequencies, you need to adjust the baud rate to 115200.

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77	0x05		0x8C	0x00: success 0xFF: failure	

Note: Set to answer mode, it must receive the read angle command to output the angle. When set to automatic output system, it will automatically output X, Y axis angle and temperature after power-on. After setting, you need to send save command (77 07 00 00 00 00 0A 11).

For example: set automatic output 5Hz transmission: 77 08 00 00 00 00 0C 01 15, return: 77 08 00 00 00 00 8C 00 94.

2.7 Set baud rate Command: 77 08 00 00 00 00 0B 00 13

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x0B	00:2400 01:4800 02:9600 03:19200	

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x8B	0x00: success 0xFF: failure	

Note: For data, 00: 2400, 01: 4800, 02: 9600, 03: 19200, 04: 115200, Default 02:9600.

2.8 Set address Command: 77 0B 00 00 00 00 0F 12 34 56 78 2E

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (4byte)	Checksum (1byte)
0x77			0x0F	XXXX Module address	

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x8F	0x00: success 0xFF: failure	

2.9 Save setting Command: 77 07 00 00 00 00 0A 11

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77			0x0A		

Command response:

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (1byte)	Checksum (1byte)
0x77			0x8A	0x00: success 0xFF: failure	

Note: If Save setting command is not executed, all setting will be invalid after power off.

2.10 Query address Command: 77 07 00 00 00 00 1F 26

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (0byte)	Checksum (1byte)
0x77	0x07		0x1F		

Command response: 77 0B 12 34 56 78 1F 12 34 56 78 52

Identifier (1byte)	Frame Length (1byte)	Address Code (4byte)	Command (1byte)	Data (4byte)	Checksum (1byte)
0x77			0x1F		

Ordering Information

Product number	Way of communication	Package condition
BWM400-60-485	RS485	Oblique section
BWM460-60-TTL	TTL	Oblique section

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

BWM400 Serials

Digital Dual-Axis Inclinator

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