BS-IC24D-M-D6EC

Inertial Measurement Unit

Instructions for use

V1.00.00

Please read this manual carefully before using this product.

Please be sure to keep this manual properly so that you can refer to it at any time in the future.

These limits only provide reasonable protection against harmful interference for the operation of the system in a commercial environment. If this equipment produces harmful interference, the user can confirm it by turning the equipment on and off. If harmful interference occurs from this equipment, the user may be able to correct the interference by:

1. Increase the distance between this device and the victim device
2. Plug the power connector of this equipment into a power outlet that uses a different circuit than the equipment that is being interfered with
3. Consult your dealer or an experienced technician for technical support

Warning!

The user's right to operate this equipment may be revoked if the equipment is altered or repaired without the express approval of the relevant authority.

Safety instructions

1、Please read these safety instructions carefully.

2、When you connect the device to the power outlet, make sure that the voltage of the power cord meets the requirements.

3、Place the power cord in a place where people cannot easily stumble over it, and do not cover the power cord with any sundries.

4、Unplug the power cord from the outlet before cleaning the unit. Do not use liquid or detergent sprays directly on the cleaning aid cloth.

5、Before installation, make sure that the equipment is placed on a reliable surface to prevent accidental dropping.

6、If the equipment is not used for a long time, please disconnect it from the power socket to prevent the equipment from being damaged by excessive voltage fluctuations.

7、Please do not allow any liquid to flow into the equipment to avoid short circuit or fire.

8、Please do not open the device by yourself. To ensure your safety, have a professional technician or certified engineer open the device. In case of

the following conditions, please repair by professional personnel:

- The equipment falls or is damaged;
- Liquid flows into the equipment;
- Power cord or plug is damaged;
- The equipment has obvious appearance damage;
- The device does not work properly, or you cannot use the user manual to make it work properly;

Table of contents

1. Overview

The BS-IC24D-M-D6EC is a high-performance inertial measurement unit that is precisely calibrated over the full temperature range to meet performance requirements under varying conditions. Built-in three-axis gyroscope and three-axis accelerometer are used to measure the three-axis angular rate, acceleration and other parameters of the carrier, and output the data after error compensation (including temperature compensation, installation misalignment angle compensation, nonlinear compensation, etc.) through SPI according to the communication protocol.

2. Performance indicators

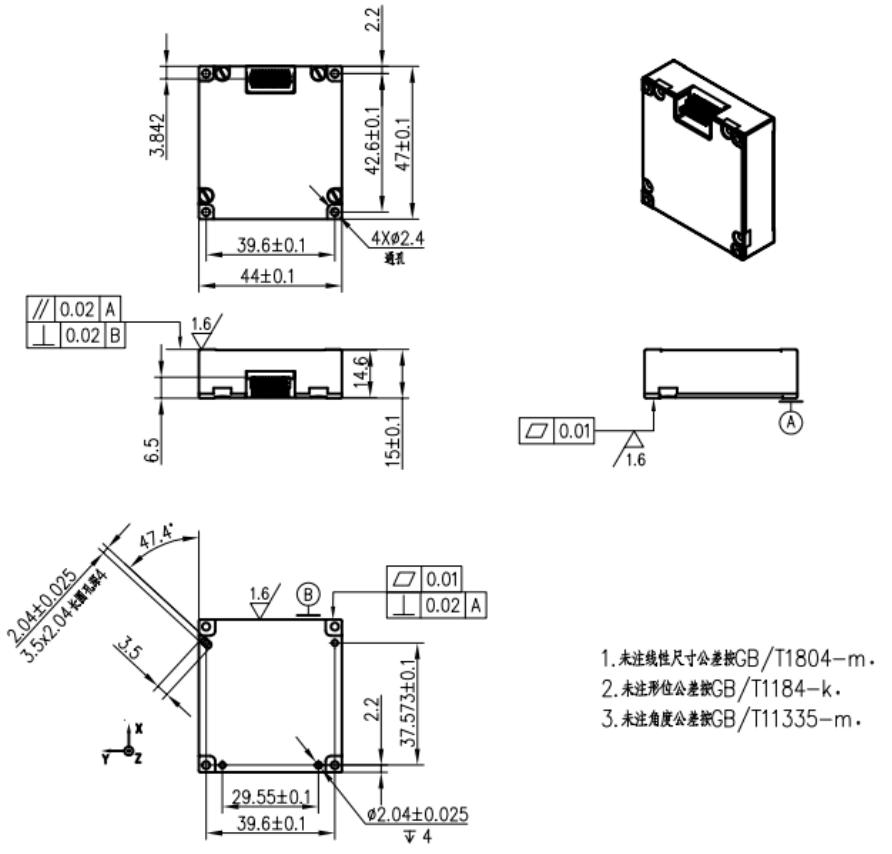
The specific performance index configuration of BS-IC24D-M-D6EC is shown in Table 1: Table 1 Performance index

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Peg-to-p	Dynamic measuring range			±500		°/s
	Zero-bias instability	Allan variance		1		°/h
	Zero bias stability	1s smooth, RMS		7		°/h
	Zero bias in full temperature range	-40 ℃ ~85 ℃, 10 s smoothing, RMS		0.007		°/s
	Random walk	1 б		0.13		°/√h
	Zero-bias repeatability	1 б		5		°/h
	Output noise	No filtering, RMS		0.02		°/s
	Scale factor nonlinearity	1 б		0.01		%
	Scale factor	FS=500 °/s		524.287		LSB/°/sec
	Bandwidth (-3dB)			150	280	Hz
	Cross coupling			0.05		%
	Acceleration			10.7		°/h/g

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
	sensitivity					
	Resonant frequency			19k		Hz
Accelerometer	Dynamic measuring range			±16		g
	Zero bias stability	Allan variance		18		ug
	Zero bias in full temperature range	-40 ℃ ~85 ℃, 10 s smoothing, RMS		0.3		mg
	Random walk	1 б		0.015		m/s/ √h
	Zero-bias repeatability	1 б		1		mg
	Output noise	No filtering, RMS		0.2		mg
	Scale factor	±16		16383		g/LSB
	Bandwidth (-3dB)			150	280	Hz
	Cross coupling			0.05		%
Magnetic force	Range			2（8）		guass
	Resolution			0.1		mg
Air pressure	Range		260		1260	hPa
	Resolution			4096		LSB/hPa
Temperature	Scale factor			0.019		° C/LSB
Communication interface	1-way SPI	Enter the clock frequency		6	12	MHz
Elec	Voltage	Direct current	3	3.3	3.6	V

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
trical characteristics	Power consumption			1		W
	Ripple	P-P		50		mV
Use environment	Operating temperature	Scalable	-40		85	℃
	Storage temperature		-55		105	℃
	Impact			2000g		

3. Appearance and structure



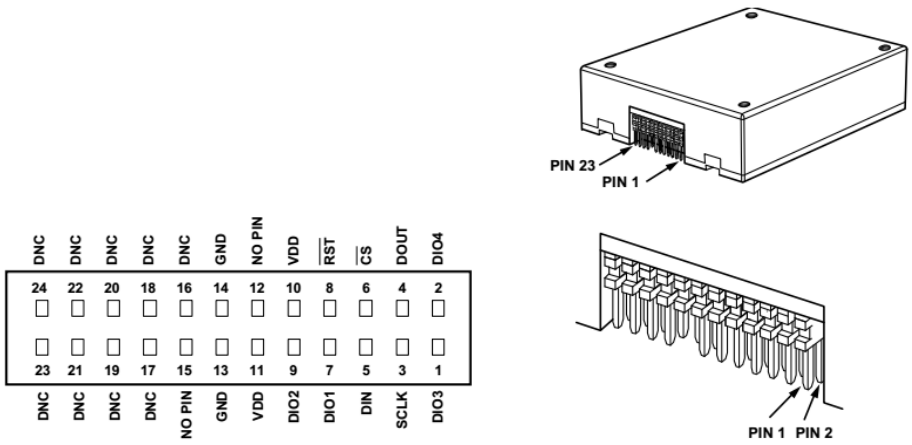


Figure 2 Appearance of BS-IC24D-M-D6EC

Table 1 Definition of contact

Pin sequence number	Name	Type	Description
10，11	VDD	Power source	
13，14	GND	Power source	
7	DIO1	Input/output	General purpose IO, configurable
9	DIO2	Input/output	
1	DIO3	Input/output	
2	DIO4	Input/output	
3	SPI-CLK	Input/output	SPI slave mode
4	SPI-MISO	Input/output	
5	SPI-MOSI	Input/output	
6	SPI-/CS	Input/output	

Other	NC	Spare	Retained by the manufacturer

The product axial direction is shown in Figure 3.

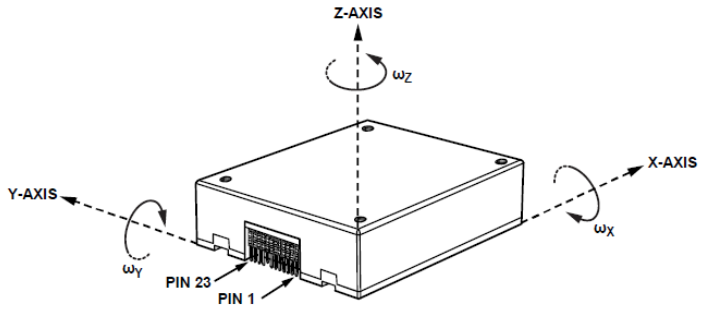


Figure 3 Product Sensitive Axial

4 Communication interface

4.1 SPI communication

The communication of IMU adopts 4-wire SPI standard interface. The maximum internal data refresh frequency of the product is 2KHz, and the maximum communication SPI rate is 12Mbps.

4.1.1 timing specification

TC = 25 ° C, VDD = 3.3 V, unless otherwise noted.

Table 2 Timing specification

Parameter	Explain	Normal mode			Unit
		Minimum value	Typical value	Maximum value	
f_{SCLK}	Serial clock	0.01		12	MHz
t_{STALL}	Stall period between data	2			μs
t_{CLS}	Serial	31			ns

	Clock Low Period				
t_{CHS}	Serial Clock High Period	31			ns
t_{CS}	Chip Select to Clock Ed	32			ns
t_{DAV}	DOUT valid after SCLK ed			10	ns
t_{DSU}	DIN setup time before SCLK rising ed	2			ns
t_{DHD}	DIN hold time after SCLK rising ed	2			ns
t_{DR}, t_{DF}	DOUT Rise/Fall Time, _ Load 100 pF		3	8	ns
t_{DSOE}	CS Asserted to Data Output Valid	0		11	ns
t_{HD}	SCLK edge to data output invalid	0			ns
t_{SFS}	Last SCLK edge to CS deasserted	32			ns
$t_{DSHI\ 0}$	CS deasserted to data output high impedance	0		9	ns

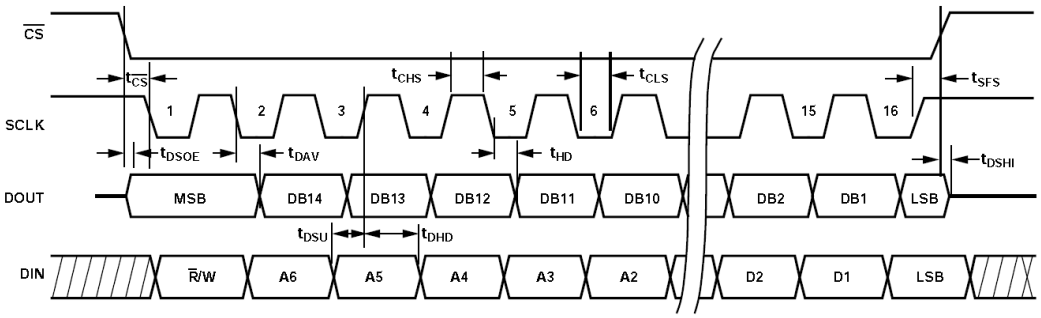


Figure 4 Timing Diagram

Figure 5. Stall Time and Data Rat

4.1.2 Data Register Address Map

The user register memory map data is defined in Table 4.

Table 3 User register memory map data

Name	R/W	PAGE_ID	Address	Default	Register description
PAGE_ID	R/W	0x00	0x00	0x00	Page identification
TEMP_OUT	R	0x00	0x0E	N/A	Temperature
X_GYRO_LOW	R	0x00	0x10,0x11	N/A	X-axis gyroscope output, low word
X_GYRO_OUT	R	0x00	0x12,0x13	N/A	X-axis gyroscope output, high word
Y_GYRO_LOW	R	0x00	0x14,0x15	N/A	Y-axis gyroscope output, low word
Y_GYRO_OUT	R	0x00	0x16,0x17	N/A	Y-axis gyroscope output, high word
Z_GYRO_LOW	R	0x00	0x18,0x19	N/A	Z-axis gyroscope output, low word
Z_GYRO_OUT	R	0x00	0x1A,0x1B	N/A	Z-axis gyroscope output, high word
X_ACCL_LOW	R	0x00	0x1C,0x1D	N/A	X-axis accelerometer output, low word
X_ACCL_OUT	R	0x00	0x1E,0x1F	N/A	X-axis accelerometer output, high word
Y_ACCL_LOW	R	0x00	0x20,0x21	N/A	Y-axis accelerometer output, low word
Y_ACCL_OUT	R	0x00	0x22,0x23	N/A	Y-axis accelerometer output, high word
Z_ACCL_LOW	R	0x00	0x24,0x25	N/A	Z-axis accelerometer output, low word

Z_ACCL_OUT	R	0x00	0x26, 0x27	N/A	Z-axis accelerometer output, high word
FILTR_BNK_0	R/W	0x03	0x16, 0x17	0x0000	Filter selection
FILTR_BNK_1	R/W	0x03	0x18, 0x19	0x0000	Filter selection
FIR_COEF_Axxx	R/W	0x05	0x02 to 0x7E	N/A	FIR Filter Bank A, Coefficient 0 through Coefficient 59
FIR_COEF_Axxx	R/W	0x06	0x02 to 0x7E	N/A	FIR Filter Bank A, Coefficient 60 through Coefficient 119
FIR_COEF_Bxxx	R/W	0x07	0x02 to 0x7E	N/A	FIR Filter Bank B, Coefficient 0 through Coefficient 59
FIR_COEF_Bxxx	R/W	0x08	0x02 to 0x7E	N/A	FIR Filter Bank B, Coefficient 60 through Coefficient 119
FIR_COEF_Cxxx	R/W	0x09	0x02 to 0x7E	N/A	FIR Filter Bank C, Coefficient 0 through Coefficient 59
FIR_COEF_Cxxx	R/W	0x0A	0x02 to 0x7E	N/A	FIR Filter Bank C, Coefficient 60 through Coefficient 119
FIR_COEF_Dxxx	R/W	0x0B	0x02 to 0x7E	N/A	FIR Filter Bank D, Coefficient 0 through Coefficient 59
FIR_COEF_Dxxx	R/W	0x0C	0x02 to 0x7E	N/A	FIR Filter Bank D, Coefficient 60 through Coefficient 119

4.1.3 SPI Communication and Configuration

Read the sensor data

A single register read requires two 16-bit SPI cycles. In the first cycle, a read of the contents of a register is requested using the bit assignment function in fig. 6; In the second cycle, the register contents are output on DOUT. The first bit of the DIN command is 0, followed by the high or low address of the register. The last eight bits are don't care, but the SPI requires a full 16 SCLKs to receive the request. Figure 5 shows two consecutive register reads, first with DIN = 0x1A00, requesting the contents of the Z _ GYRO _ OUT register, and then with DIN = 0x1800, requesting the contents of the Z _ GYRO _ LOW register.

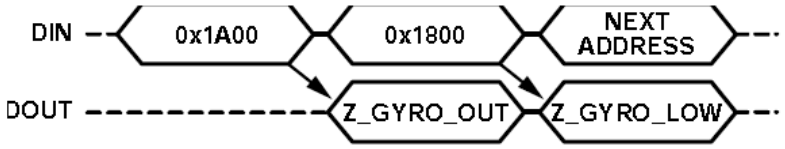


Figure 6. SPI Read Example

5 SPI Data Register

After the BS-IC24D-M-D6EC starts the process, the PAGE _ ID register value is 0 x0000, which sets Page 0 as the valid page for SPI access. Page 0 contains the output data, product identification registers.

5.1 inertial sensor data format

The output data registers for the gyroscopes and accelerometers use a 32-bit, twos complement format. Two registers per output are used to support this resolution. Figure 7 illustrates the role of each register in various inertial measurements by way of example. In this example, the X _ GYRO _ OUT is the most significant word (upper 16 bits) and the X _ GYRO _ LOW is the least significant word (lower 16 bits). In many cases, using only the most significant word register provides enough resolution to reflect the key performance metrics.

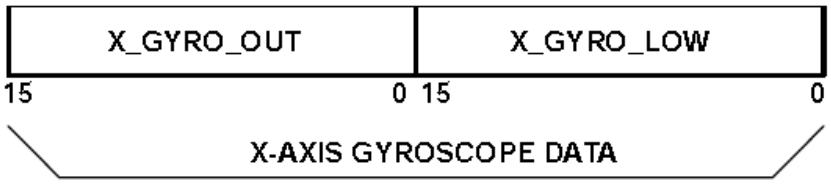


Figure 7. Gyro Data Output Example

5.1.1 Gyroscope

The main registers used for gyroscope measurements use the X _ GYRO _ OUT format (see Table 5, Table 6, and Table 7). The 16-bit twos complement data format is used when processing data from

these registers. Table 8 show an example of that digital encoding of the X _ GYRO _ OUT.

Table 4 X _ GYRO _ OUT (Page 0, Base Address = 0x12)

Bit	Explain
[15:0]	X-axis gyroscope data; Twos complement, ± 450 ° /sec range, 0 ° /sec = 0 X 0000,1 LSB = 0.025 ° /sec

Table 5 Y _ GYRO _ OUT (Page 0, Base Address = 0x16)

Bit	Explain
[15:0]	Y-axis gyroscope data; Twos complement, ± 450 ° /sec range, 0 ° /sec = 0 X 0000,1 LSB = 0.025 ° /sec

Table 6 Z _ GYRO _ OUT (Page 0, Base Address = 0x1A)

Bit	Explain
[15:0]	Z-axis gyroscope data; Twos complement, ± 450 ° /sec range, 0 ° /sec = 0 X 0000,1 LSB = 0.025 ° /sec

Table 7 Example of X _ GYRO _ OUT data format

Rotation rate	Decimal system	Hexadecimal	Binary
+450°/sec	+18,000	0x4650	0100 0110 0101 0000
+0.05/sec	+2	0x0002	0000 0000 0000 0010
+0.025°/sec	+1	0x0001	0000 0000 0000 0001
0°/sec	0	0x0000	0000 0000 0000 0000
-0.025°/sec	-1	0xFFFF	1111 1111 1111 1111
-0.05°/sec	-2	0xFFFE	1111 1111 1111 1110
-450°/sec	-18,000	0xB9B0	1011 1001 1011 0000

Registers using the X _ GYRO _ LOW naming format are used to increase the resolution of the gyroscope measurements (see Table 9, Table 10, and Table 11). The MSB has a weight of 0.0125 ° /sec, and the subsequent bits have a weight of ½ of the previous bit.

Table 8 X _ GYRO _ LOW (Page 0, Base Address = 0x10)

Bit	Explain
[15:0]	X-axis gyroscope data; Additional resolution bit

Table 9 Y _ GYRO _ LOW (Page 0, Base Address = 0x14)

Bit	Explain
[15:0]	Y-axis gyroscope data; Additional resolution bit

Table 10 Z _ GYRO _ LOW (Page 0, Base Address = 0x18)

Bit	Explain
[15:0]	Z-axis gyroscope data; Additional resolution bit

5.1.2 Accelerometer

The main registers for accelerometer measurements use the X _ ACCL _ OUT format (see Table 12, Table 13, and Table 14). The 16-bit twos complement data format is used when processing data from these registers. Table 15 shows an example of X _ ACCL _ OUT digital encoding.

Table 11 X _ ACCL _ OUT (Page 0, Base Address = 0 x1E)

Bit	Explain
[15:0]	X-axis accelerometer data; Twos complement, ± 20 G range, 0 G = 0x 0000,1 LSB = 1 mg

Table 12 Y _ ACCL _ OUT (Page 0, Base Address = 0x22)

Bit	Explain
[15:0]	Y-axis accelerometer data; Twos complement, ± 20 G range, 0 G = 0x 0000,1 LSB = 1 mg

Table 13 Z _ ACCL _ OUT (Page 0, Base Address = 0x26)

Bit	Explain
[15:0]	Z-axis accelerometer data; Twos complement, ± 20 G range, 0 G = 0x 0000,1 LSB = 1 mg

Table 14 Example of X _ ACCL _ OUT data format

Acceleration	Decimal system	Hexadecimal	Binary
+20g	+20,000	0x4E20	0100 1110 0010 0000
+2mg	+2	0x0002	0000 0000 0000 0010
+1mg	+1	0x0001	0000 0000 0000 0001
0 mg	0	0x0000	0000 0000 0000 0000
-1mg	-1	0xFFFF	1111 1111 1111 1111
-2mg	-2	0xFFFE	1111 1111 1111 1110
-20g	-20,000	0xB1E0	1011 0001 1110 0000

Registers using the X _ ACCL _ LOW naming format are used to improve the resolution of the accelerometer measurements (see Table 16, Table 17, and Table 18). The MSB has a weight of 0.5 mg, and subsequent bits have a weight of ½ of the previous bit.

Table 15 X _ ACCL _ LOW (Page 0, Base Address = 0 X 1C)

Bit	Explain
[15:0]	X-axis accelerometer data; Additional resolution bit

Table 16 Y _ ACCL _ LOW (Page 0, Base Address = 0 x20)

Bit	Explain
[15:0]	X-axis accelerometer data; Additional resolution bit

Table 17 Z _ ACCL _ LOW (Page 0, Base Address = 0x24)

Bit	Explain
[15:0]	X-axis accelerometer data; Additional resolution bit

5.1.3 internal temperature

The TEMP _ OUT register provides an internal temperature

measurement that can be used to observe relative temperature changes within the product (see Table 19). Table 20 shows an example of TEMP _ OUT digital encoding. Note that this temperature is higher than the ambient temperature due to self-heating effects.

Table 18 TEMP _ OUT (Page 0, Base Address = 0x0E)

Bit

Bit	Explain
[15:0]	Temperature data; Twos complement, 0.0125 ° C/LSB, 25 ° C = 0x0000

Table 19 Example of TEMP _ OUT data format

Temperature	Decimal system	Hexadecimal	Binary
+85	+4800	0x12C0	0001 0010 1100 0000
+25 + 0.0113	+2	0x0002	0000 0000 0000 0010
+25 + 0.00565	+1	0x0001	0000 0000 0000 0001
+25	0	0x0000	0000 0000 0000 0000
+25 - 0.00565	-1	0xFFFF	1111 1111 1111 1111
+25 - 0.0113	-2	0xFFFE	1111 1111 1111 1110
-40	-5200	0xEBB0	1110 1011 1011 0000

6 Functional testing

6.1 Wiring method

If the user can access this data through the SPI port, see Figure 8 for a connection diagram.

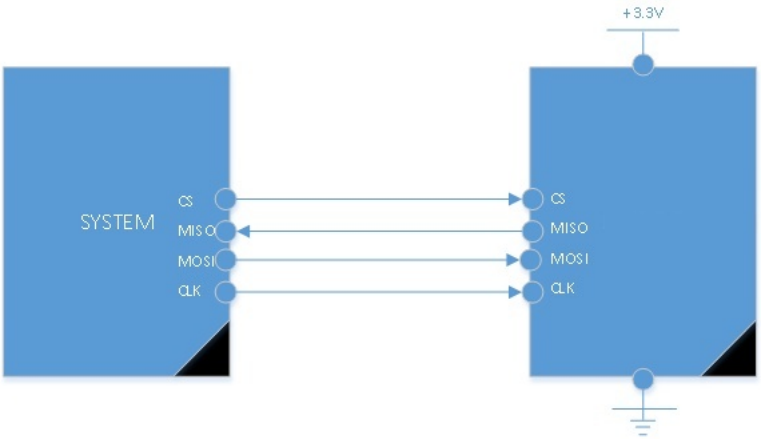


Figure 8. SPI Wiring Diagram

6.2 Functional testing

The external MCU reads the register data of BS-IC24D-M-D6EC inertial measurement unit through SPI, calculates the parameters of gyroscope and accelerometer according to the corresponding method, and verifies the function of the product through the data.

7 Installation and adjustment

The BS-IC24D-M-D6EC three-axis gyroscope assembly is installed through four Φ2.5 through holes with screws. When installing the connector, the plug should correspond to each pin of the socket and be fixed by screws.

It is recommended that the flatness of the mounting surface opposite to the datum plane should not be greater than the 0.02 mm, the 垂直度不大于 0.04 mm, and the surface roughness should not be greater than 0.8 μm.

8 Operation and maintenance requirements

Before use, the installation position of the system must be checked to ensure correct installation. Carefully check the connection of each signal line to ensure that the connection is correct.

Before power-on, check the cable network contact and power supply value, and the power supply polarity shall not be reversed.

In use, the mechanical grounding of the system shall be well grounded.

This product should be stored in a well-ventilated warehouse with a temperature of (15 ~ 35) ℃, a relative humidity of not more than 75%, and free of acid, alkali and corrosive gases.

Appendix A Packing List

BS-IC24D-M-D6EC product matching table

Serial number	Name	Quantity	Unit	Remark
1	BS-IC24D-M-D6EC products	1	Taiwan	
2	Product certificate	1	Share	
3	Instructions for use	1	Share	
4	Packing list	1	Share	
5	Product packing box	1	A	

Precautions for use and maintenance

1、 pay attention to the range of accelerometers and gyroscopes

of the equipment to avoid overrange of the equipment.

The 2、 shall pay attention to the power supply voltage of the equipment, and the power supply of the equipment shall avoid overvoltage and undervoltage.

The 3、 notes the transmission distance of the device's output data.

4、 to avoid hot plugging, that is, to avoid live plugging.

The 5、recommends a self-test at least once every three months.

Do not drop the 6、: internal structural parts may be damaged due to high-altitude drop, impact, etc.

The 7、 prevents corrosive liquids from corroding the navigator or from being immersed in any liquid.

8、 to avoid radiated interference: Radiated interference from other electronic equipment may interfere with proper operation.

Maintenance precautions

In the process of installation and use, if the following phenomena occur, please contact our engineers to determine whether it can continue to use or return to the factory for maintenance.

The appearance of the 1、 has obvious damage marks, including serious scratches, bumps, missing parts, etc.

The 2、 can not be installed to the bracket normally, or the installation accuracy requirements can not be met after installation.

The electrical interface of the 3、 is damaged.

The 4、 is electrified under normal temperature and normal pressure, and the 3.3 V is 工作电流大于 0.5 A.

The 5、 fails to receive data normally or receives incorrect data.

The 6、 is used under the operating conditions specified in the operating instructions, and the performance indicators are seriously inconsistent with those specified in the operating instructions.

* The above terms are based on the service life of the contract and the warranty policy.