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BS-IC24HA-M-D6EC

High-precision version of inertial measurement unit

R2.900.002SM

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This instruction manual is the main document for the operation of the BS-IC24HA-M-D6EC inertial measurement unit.

This instruction manual is mainly compiled in accordance with the Technical Specifications for Inertial Measurement Unit and Three-axis Gyroscope Unit.

1. Product functions and relevant technical parameters

1.1 Composition and function

The BS-IC24HA-M-D6EC inertial measurement unit is a complete inertial system with a built-in three-axis gyroscope and a three-axis accelerometer, which is 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.

1.2 Main technical parameters

表 1 Technical parameters

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Gyro	Dynamic measuring range			±450		°/s
	Bias instability	Allan variance, better than		0.3		°/h
	Bias stability	1s smooth, RMS, better than		10		°/h
	Bias in full temperature range	-40 °C ~ 85 °C, 10 s smoothing, RMS		0.005		°/s
	Random walk	1б		0.15		°/√h
	Bias repeatability	1б		10		°/h
	Output noise	No filtering, RMS		0.05		°/s
	Scale factor repeatability	1б		0.01		%
	Scale factor nonlinearity	1б		0.01		%
	Scale factor	FS=450 °/s, 32bits		2621440		LSB/°/sec

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Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
	Bandwidth (-3dB)			250		Hz
	Cross coupling			0.1		%
	Acceleration sensitivity			1		°/h/g
	Vibration rectification effect			0.5		°/h/g2
	Resonant frequency			12k		Hz
Accelerometer	Dynamic measuring range			±20		g
	Bias stability	Allan variance		2		ug
	Bias in full temperature range	-40 ℃ ~ 85 ℃, 10 s smoothing, RMS		1		mg
	Random walk	1б		0.029		m/s/√h
	Bias repeatability	1б		5		mg
	Output noise	No filtering, RMS		0.5		mg
	Scale factor repeatability	1б		0.1		%
	Scale factor nonlinearity	FS=20g		0.1		%FS
	Scale factor	±20, 32bits		65536000		g/LSB
	Bandwidth (-3dB)			250		Hz
	Cross coupling			0.1		%
Temperature	Scale factor			0.0125		°C/LSB
Communication interface	1-way SPI	Enter the clock frequency		8	15	MHz
Electrical characteristics	Voltage	Direct current		3.3 ± 10%		V
	Power consumption			1	1.5	W
	Ripple	P-P		48±2	100	mV
Use	Operating	Scalable	-40		85	℃

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Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
environment	temperature					
	Storage temperature		-55		85	℃
	Vibration			10~2000Hz，6.06g		
	Impact			1000g，0.1ms		

2 Structural features and electrical connections

The outline drawing of the BS-IC24HA-M-D6EC IMU is shown in Figure 1.

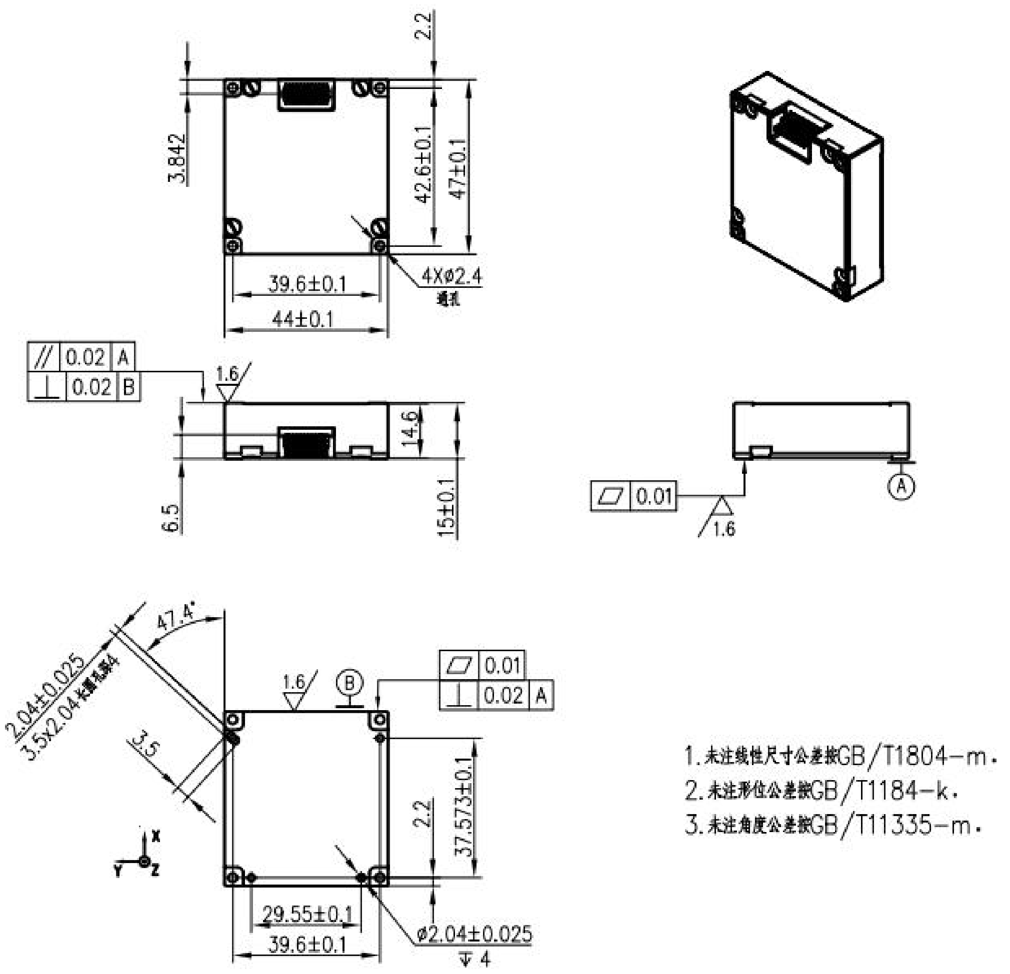

Figure 1 Outline drawing

The model of the connector connecting the product to the outside is FTMH-112-02-H-DH. See Table 2 for the definition of the contact. The corresponding connector model is CLM-112-02-GDA.

The connector is as shown in the figure.

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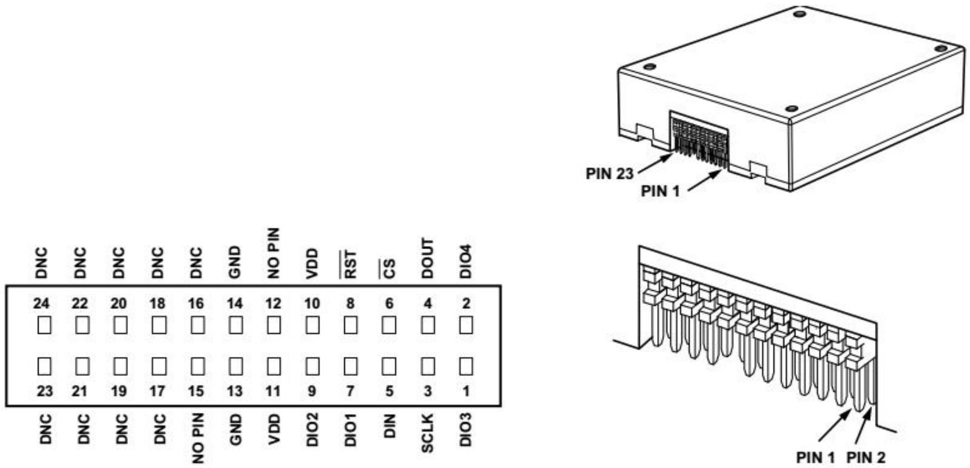

Fig. 2 Connector

表 2 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.

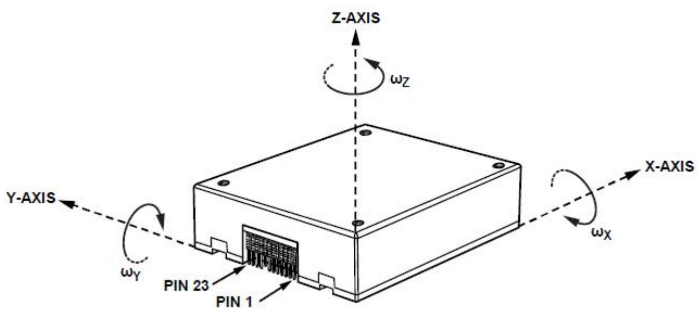

Figure 3 Product Sensitive Axial

3 Communication interface

3.1 SPI communication

The communication of IMU adopts 4-wire SPI standard interface. The maximum internal data refresh frequency of the product is 2.4KHz, and the maximum communication SPI rate is 15Mbps.

3.1.2 Timing specification

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

表 3 Timing specification

Parameter	Explain	Normal mode			Unit
		Minimum value	Typical value	Maximum value	
fSCLK	Serial clock	0.01		15	MHz
tSTALL	Stall period between data	2			μs
tCLS	Serial Clock Low Period	31			ns
tCHS	Serial Clock High Period	31			ns
tCS	Chip Select to Clock Ed	32			ns
tDAV	DOUT valid after SCLK ed			10	ns
tDSU	DIN setup time before SCLK rising ed	2			ns
tDHD	DIN hold time after SCLK rising ed	2			ns
tDR, tDF	DOUT Rise/Fall Time, _ Load		3	8	ns

	100 pF				
tDSOE	CS Asserted to Data Output Valid	0		11	ns
tHD	SCLK edge to data output invalid	0			ns
tSFS	Last SCLK edge to CS deasserted	32			ns
tDSHI 0	CS deasserted to data output high impedance	0		9	ns

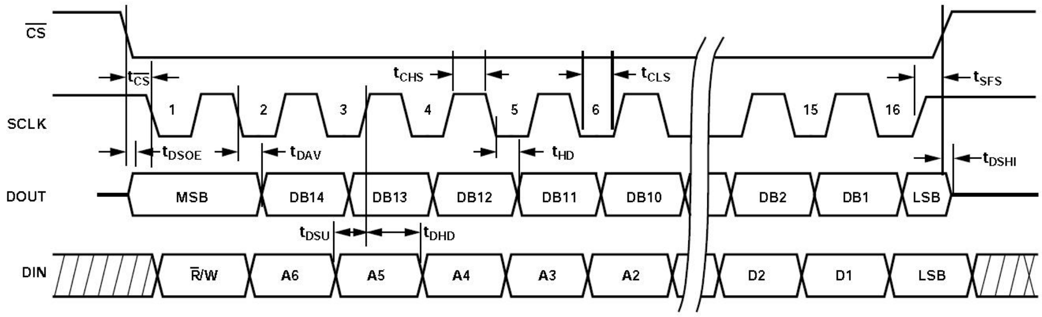

Figure 4 Timing Diagram

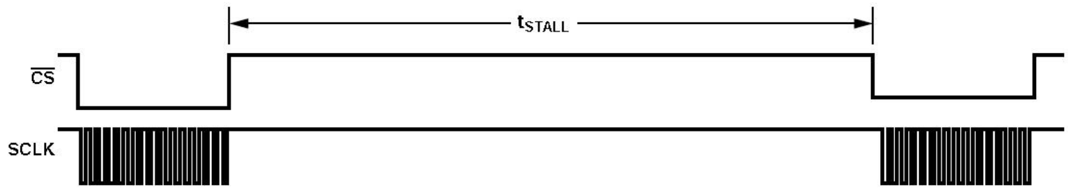

Figure 5. Stall Time and Data Rat

3.1.3 Data Register Address Mapping

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

表 4　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

3.1.4 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 Figure 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 the full 16 SCLKs to receive the request. Figure 5 shows two consecutive register reads, starting with DIN = 0x1A00, requesting the contents of the Z _ GYRO _ OUT register, followed by DIN = 0x1800, requesting the contents of the Z _ GYRO _ LOW register.

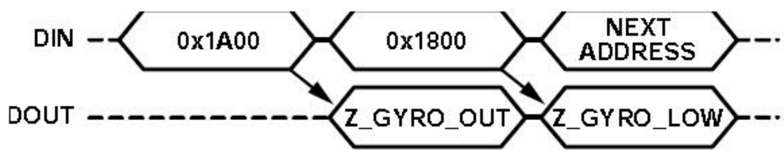

Figure 6. SPI Read Example

4 SPI Data Register

After the BS-IC24HA-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.

4.1 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.

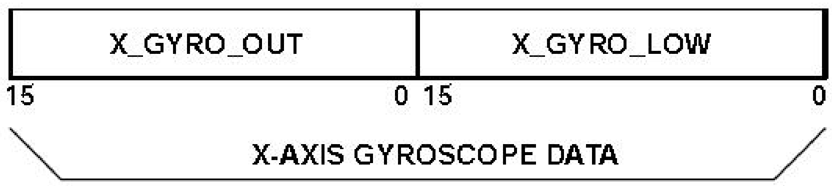

Figure 7. Gyro Data Output Example

4.1.1 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.

表 5　X _ GYRO _ OUT (Page 0, Base Address = 0x12)

Bit	Explain
[15:0]	X-axis gyroscope data; twos complement, ± 450 °/sec range, 0 °/sec = 0x0000, 1 LSB = 0.025 °/sec

表 6　Y _ GYRO _ OUT (Page 0, Base Address = 0x16)

Bit	Explain

[15:0]	Y-axis gyroscope data; twos complement, ± 450 °/sec range, 0 °/sec = 0x0000, 1 LSB = 0.025 °/sec

表 7 Z _ GYRO _ OUT (Page 0, Base Address = 0x1A)

Bit	Explain
[15:0]	Z-axis gyroscope data; twos complement, ± 450 °/sec range, 0 °/sec = 0x0000, 1 LSB = 0.025 °/sec

表 8 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 subsequent bits have a weight of ½ of the previous bit.

表 9 X _ GYRO _ LOW (Page 0, Base Address = 0x10)

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

表 10 Y _ GYRO _ LOW (Page 0, Base Address = 0x14)

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

表 11 Z _ GYRO _ LOW (Page 0, Base Address = 0x18)

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

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4.1.2 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.

表 12 X _ ACCL _ OUT (Page 0, Base Address = 0 x1E)

Bit	Explain
[15:0]	X-axis accelerometer data; twos complement, ± 20 G range, 0 G = 0x0000, 1 LSB = 1 mg

表 13 Y _ ACCL _ OUT (Page 0, Base Address = 0x22)

Bit	Explain
[15:0]	Y-axis accelerometer data; twos complement, ± 20 G range, 0 G = 0x0000, 1 LSB = 1 mg

表 14 Z _ ACCL _ OUT (Page 0, Base Address = 0x26)

Bit	Explain
[15:0]	Z-axis accelerometer data; twos complement, ± 20 G range, 0 G = 0x0000, 1 LSB = 1 mg

表 15 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

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bits have a weight of ½ of the previous bit.

表 16 X _ ACCL _ LOW (Page 0, Base Address = 0 X 1C)

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

表 17 Y _ ACCL _ LOW (Page 0, Base Address = 0 x20)

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

表 18 Z _ ACCL _ LOW (Page 0, Base Address = 0x24)

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

4.1.5 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.

表 19 TEMP _ OUT (Page 0, Base Address = 0x0E) Bit

Bit	Explain
[15:0]	Temperature data; twos complement, 0.0125 ° C/LSB, 25 ° C = 0 X 0000

表 20 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

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5 Functional testing

5.1 Wiring method

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

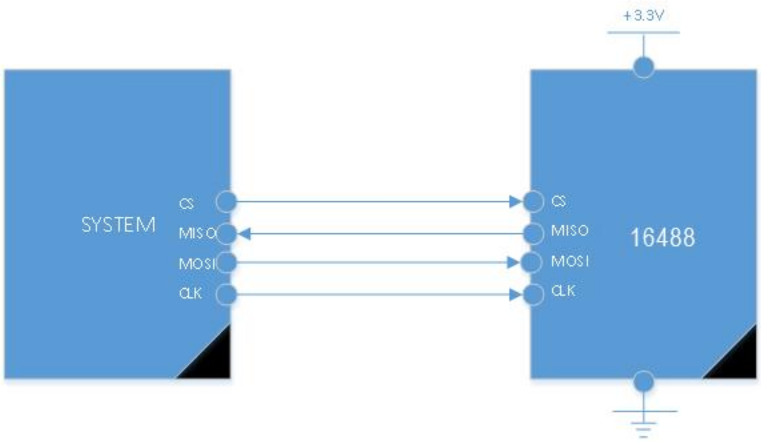

Figure 8. SPI Wiring Diagram

5.2 Functional test

The external MCU reads the register data of BS-IC24HA-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.

6 Installation and adjustment

The BS-IC24HA-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 reference surface shall not be greater than 0.02 mm, the verticality shall not be greater than 0.04 mm, and the surface roughness shall not exceed 0.8 μm.

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7 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-IC24HA-M-D6EC product matching table

Serial number	Name	Quantity	Unit	Remark
1	BS-IC24HA-MD6EC products	1	Pcs	
2	Product certificate	1	Pcs	
3	Instructions for use	1	Pcs	
4	Packing list	1	Pcs	
5	Product packing box	1	A	