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BS-IU30-M-D6EC

MEMS Inertial Measurement Unit Instruction Manual

R2.900.006SM

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This instruction manual is the main reference document for the operation of BS-IU30-M-D6EC inertial measurement unit.

This manual is prepared in accordance with BS-IU30-M-D6EC Technical Conditions, BS-IU30-M-D6EC MEMS Inertial Measurement Unit Protocol and RJT-001 Technical Conditions for Inertial Measurement Unit and Triaxial Gyro Combination.

BS-IU30-M-D6EC inertial measurement unit can change the measurement accuracy and measurement range of the inertial sensor according to the user's requirements.

1 Product features and technical parameters

1.1 Composition and function

The MEMS Inertial Measurement Unit (IMU) consists of three-axis gyroscope, three-axis accelerometer, temperature sensor, signal processing board, structure and necessary software, and is used to measure the three-axis angular rate, three-axis acceleration and three-axis inclination of the carrier. And output that data of the gyroscope and the loading table aft error compensation (including temperature compensation, installation misalignment angle compensation, nonlinear compensation and the like) through an RS-422 serial port according to an agreed communication protocol.

1.2 Main technical parameters

1.2.1 Gyroscope specifications

Parameter	Unit	BS-IU30-M-D6EC
Measuring range (customizable)	°/s	±200
Bias stability (@ Allan variance)	°/h	0.2
Bias stability (10 s smoothing, 1σ, room temperature)	°/h	0.5
Bias error over full temperature range	°/h	2.5
Random walk	°/√h	0.02
Bias repeatability	°/h	1
Zero bias acceleration sensitivity	°/h/g	1

Resolution	°/h	2
Scale factor nonlinearity	ppm	100
Scale factor repeatability	ppm	100
Cross coupling	%	0.2
Bandwidth	Hz	100

1.2.2 Add table technical indicators

Parameter	**Unit**	**BS-IU30-M-D6EC**
Measuring range (customizable)	g	±30
Bias stability (Allan Variance @ 25 ℃)	ug	30
Bias stability (1s smoothing)	ug	700
Bias error over full temperature range	mg	1.5
Random walk	m/s/√h	0.01
Bias repeatability	mg	2
Scale factor repeatability	ppm	200
Scale factor nonlinearity	ppm	200
Cross coupling	%	0.2
Bandwidth	Hz	100

1.2.3 Electrical characteristics

Parameter	**Unit**	**BS-IU30-M-D6EC**
Voltage	V	5
Power consumption	W	1.5
Ripple	mV	100

1.2.4 Environmental adaptability

Parameter	**Unit**	**BS-IU30-M-D6EC**
Operating temperature	℃	-45~85
Storage temperature	℃	-60~105
Vibration	--	10~2000Hz，6.06g

Impact	--	15000g,4ms

1.2.5 Other

Parameter	**Unit**	**BS-IU30-M-D6EC**
Weight	g	120

2 Space coordinate system

2.1 Right Hand Rule Principle 1

The MEMS IMU contains three axial spatial coordinate systems, namely X, Y and Z. The X axis points to the top surface of the IMU, the Y axis points to the direction of the electrical connection interface, and the Z axis refers to the right side of the IMU, as shown in Figure 2-1.

Figure 2-1 Space Coordinate System of Inertial Measurement Unit

The installation of the inertial measurement unit should match the axial direction of the coordinate system, otherwise the measured angular velocity data is not accurate. The axis of the coordinate system can be quickly assigned and determined by following the "right-hand rule principle 1". Stretch out the right hand and spread out the thumb, index finger and middle finger respectively. The direction of the thumb is the X axis, the direction of the index finger is the Y axis, and the direction of the middle finger is the Z axis, as shown in Figure 2-2.

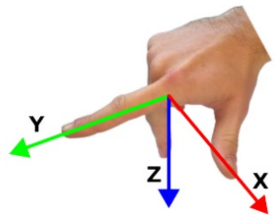

Figure 2-2 Right Hand Rule Principle 1

2.2 Right hand rule principle two

The three-degree-of-freedom gyroscope in the inertial measurement unit can measure the angular velocity in three directions. The direction of the angular velocity of the axial rotation of the coordinate axis can be quickly determined by following the'right-hand rule principle 2 '. Stretch out the right hand and spread out the thumb. The direction of the thumb is the axial direction, and the direction of the other four fingers is the angular velocity of the axial rotation of the thumb, as shown in Figure 2-3.

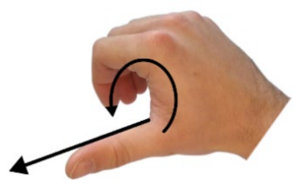

Figure 2-3 Right Hand Rule Principle 2

3 Structural installation

Refer to Figure 3-1 for outline drawing of BS-IU30-M-D6EC inertial measurement unit.

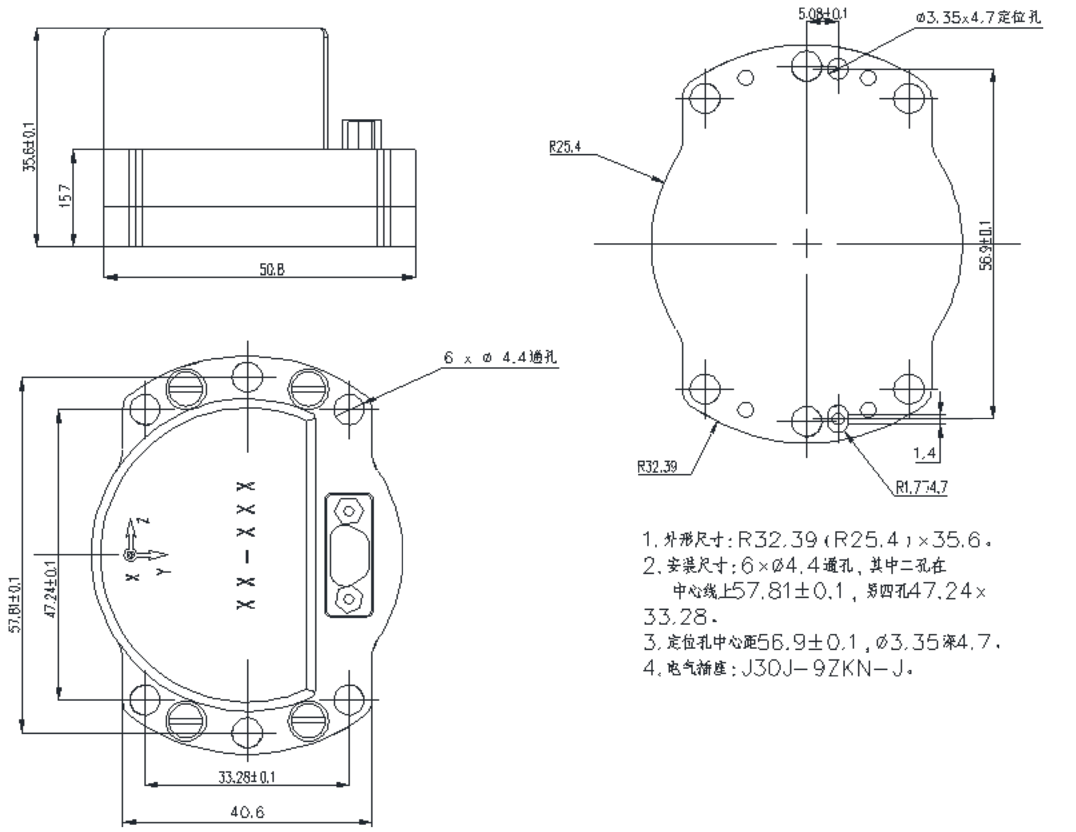

Figure 3-1 Outline drawing of inertial measurement unit

The BS-IU30-M-D6EC inertial measurement unit has two φ3.35 positioning holes with a depth of 4.7, and the center distance of the positioning holes is 56.9 ± 0.1; 6 φ4.4 through holes, 2 of which are 57.81 ± 0.1 on the center line, and the other 4 are 47.24 × 33.28. When installing, position first, and then install through the hole.

4 Electrical characteristics

The model of external electrical connector of BS-IU30-M-D6EC is J30J-9 ZKN-J, and the model of connector connected with it is J30J-9 TJ. See Table 4-1 for the specific distribution of product connector nodes, and see Fig. 4-1 for the connector node diagram.

Table 4-1 J30J-9ZKN-J Contact Distribution

Node number	Definition	Use
1	Tx+	Product output RS422
2	Tx-	

3	Rx+	The product receives RS422
4	Rx-	
5	GND	Power ground
6	+5V	Power supply positive
7	EXT	External trigger, 3.3 V TTL level, falling edge active
8,9	NC	Hanging in the air

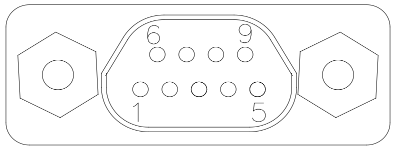

Figure 4-1 J30J-9ZK Node Distribution Diagram

5 Communication interface

5.1 Configurable parameters

The product communication protocol can be configured through the upper computer software, and the configurable parameters are shown in Table 5-1 below.

Table 5-1 Product Configurable Parameters

Parameter	Configuration value		Explain
Data frame	Gyro data frame (ID = 0x90) 'Gyro + Add Table 'data frame (ID = 0x91) 'Gyro + Tilt 'data frame (ID = 0x92) 'Gyro + Add Table + Tilt 'data frame (ID = 0x93) 'Gyro + Temperature 'data frame (ID = 0x94) 'Gyro + plus meter + temperature 'data frame (ID = 0 xA5) 'Gyro + tilt + temperature 'data frame (ID = 0 xA6) 'Gyro + plus meter + tilt + temperature 'data frame (ID = 0 xA7)		See Section 5.3 for the specific data frame format, and you can choose one of them to send. See Table 5-2 for the relationship between data frame, baud rate and update rate.
RS422 baud rate	460800bps 921600bps		Refer to Table 5-2 for baud rate limit conditions.
RS422 check digit	NONE (no check) ODD (odd parity) EVEN (even parity)		
RS422 stop bit	1 bit 2 bits		
Low-pass filter bandwidth	-3dB frequency	Group Delay (ms)	The filter setting is independent of the data update rate. The low-pass filter is a second-order IIR.
	16Hz 33Hz 66Hz 131Hz 262Hz	23.4 11.7 5.9 3.0 1.6	
Data update rate	125Hz 250Hz		Refer to Table 5-2 for data update rate

	500Hz 1000Hz	restrictions.
Restore factory settings	Restore factory settings Restore factory settings and save	

5.2 Communication interface

It communicates with the processing circuit unit through the serial communication interface and adopts the RS-422 standard. Both the transmission baud rate and the data update rate can be configured by software. Table 5-2 shows the maximum data update rate corresponding to the transmission baud rate.

In the default state of the product, the communication protocol is: baud rate 921 600bps, 8 data bits, 1stop bit, no check bit, 0xA5 data frame, update rate 1000Hz.

Table 5-2 Maximum Data Update Rate

Baud rate / Data frame format	**460800 bit/s**	**921600 bit/s**
Gyro data frame (0x90)	1000Hz	1000 Hz
'Gyro + Add Table 'data frame (0 x91)	1000 Hz	1000 Hz
'Gyro + Tilt 'data frame (0x92)	1000 Hz	1000 Hz
'Gyro + plus meter + tilt 'data frame (0x93)	1000 Hz	1000 Hz
'Gyro + Temperature 'data frame (0x94)	1000 Hz	1000 Hz
'Gyro + plus meter + temperature 'data frame (0 xA5)	500 Hz	1000 Hz
'Gyro + tilt + temperature 'data frame (0 xA6)	500 Hz	1000 Hz
'Gyro + plus meter + tilt + temperature 'data frame (0 xA7)	500 Hz	1000 Hz

5.3 Data frame format

The inertial measurement unit sends data frames in each cycle. The data format can be configured by referring to the corresponding data frame format in the operating instructions of the supporting upper computer. All formats are shown in the following table.

Table 5-2 Data Frame Format of Gyro

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0x90	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.

3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	Frame counter	[0，255]	1	1	0-255 continuous count
7	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
8	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-3 Data Frame Format of "Gyro + Add Table"

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0x91	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
7	Y-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	

8	Z-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
9	Add table status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	Frame counter	[0，255]	1	1	0-255 continuous count
11	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
12	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-4 Format of 'Gyro + Tilt' Data Frame

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0x92	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
7	Y-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
8	Z-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.

9	Inclination state	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	Frame counter	[0，255]	1	1	0-255 continuous count
11	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
12	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-5 Data Frame Format of 'Gyro + Add Table + Dip Angle'

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0x93	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis acceleration	[-10，10] [-30，30] [-50，50]	3	2^{-19} 2^{-18} 2^{-17}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
7	Y-axis acceleration	[-10，10] [-30，30] [-50，50]	3	2^{-19} 2^{-18} 2^{-17}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
8	Z-axis acceleration	[-10，10] [-30，30] [-50，50]	3	2^{-19} 2^{-18} 2^{-17}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
9	Add table status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.

10	X-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
11	Y-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
12	Z-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
13	Inclination state	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
14	Frame counter	[0，255]	1	1	0-255 continuous count
15	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
16	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-6 Format of 'Gyro + Temperature' Data Frame

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0x94	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.

7	Y-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
8	Temperature of Z-axis gyroscope	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
9	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	Frame counter	[0，255]	1	1	0-255 continuous count
11	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
12	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-7 Data Frame Format of 'Gyro + Add Table + Temperature'

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0xA5	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
7	Y-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
8	Z-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most

		[-30，30]		2^{-18}	significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-50，50]		2^{-17}	
9	Add table status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	X-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
11	Y-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
12	Temperature of Z-axis gyroscope	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
13	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
14	X-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
15	Y-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
16	Z-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
17	Add thermometer status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
18	Frame counter	[0，255]	1	1	0-255 continuous count
19	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
20	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-8 Format of 'Gyro + Tilt + Temperature' Data Frame

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0xA6	1	——	Packet header

2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyroscope status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
7	Y-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
8	Z-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
9	Inclination state	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	X-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
11	Y-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
12	Temperature of Z-axis gyroscope	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
13	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
14	X-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.

15	Y-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
16	Z-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
17	Dip Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
18	Frame counter	[0，255]	1	1	0-255 continuous count
19	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
20	CRC32	——	4	——	CRC32 verification, see instruction 6

Table 5-9 Data Frame Format of 'Gyro + Add Table + Inclination + Temperature'

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0xA7	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit: (/s, from high to low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
5	Gyroscope status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
7	Y-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
8	Z-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most

		[-30，30]		2^{-18}	significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-50，50]		2^{-17}	
9	Add table status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	X-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
11	Y-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
12	Z-axis inclination	[-1.7，1.7]	3	2^{-22}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
13	Inclination state	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
14	X-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
15	Y-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
16	Temperature of Z-axis gyroscope	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
17	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
18	X-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
19	Y-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
20	Z-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
21	Add thermometer status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.

22	X-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
23	Y-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
24	Z-axis tilt temperature	[-128，128]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
25	Dip Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
26	Frame counter	[0，255]	1	1	0-255 continuous count
27	Delay		2		Unit: us, first high and then low, the most significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
28	CRC32	——	4	——	CRC32 verification, see instruction 6

Explain

1) Gyro angular velocity output [°/s] $=\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^{14}}$ See Figure 5-1 for data bit format;

Among AR_1 Outputting the high eight bits of the three bytes for the angular velocity of each axis of the gyroscope;

AR_2 Outputting the middle eight bits of the three bytes for the angular velocity of each axis of the gyroscope;

AR_3 Outputs the lower eight bits of the three bytes for the angular velocity of each axis of the gyro.

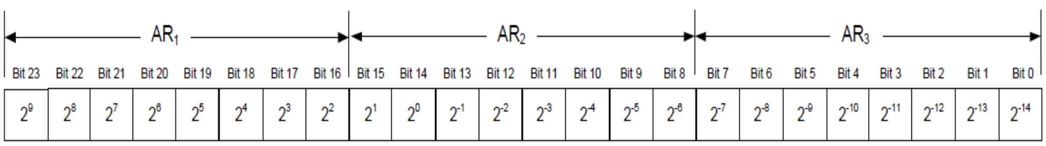

Figure 5-1 Converting the Gyro Angular Velocity Output to [°/s]

2) Acceleration speed output [G] $=\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^X}$;

Among AR_1 Outputs the upper eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_2 Outputs the middle eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_3 Outputs the lower eight bits of the three bytes for the angular velocity of each axis of the accelerometer.

X is the tabulated scale index, and 10g, 30g, and 50g are tabulated for X = 19, 18, and 17.

3) Tilt speed output [G] $= \frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^{22}}$;

Among AR_1 Outputs the upper eight bits of the three bytes for the angular velocity of each axis of the tilt angle;

AR_2 The middle eight bit of that three bytes are output for the angular velocity of each axis of the tilt angle;

AR_3 The lower eight bits of the three bytes are output for the angular velocity of each axis of the tilt angle.

4) Temperature output [℃] $= \frac{T_1 \cdot 2^8 + T_2}{2^8}$? See Figure 5-2 for data bit format.

Among T_1 Outputs the upper eight bits of the two bytes for each axis temperature;

T_2 Outputs the lower eight bits of the two bytes for each axis temperature.

T_1								T_2							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}

Figure 5-2 Converting Temperature Output to [℃]

5) Delay time output [us] = $T_1 \cdot 2^8 + T_2$

Where: T_1 is the high eight bits in the two bytes of the delay time output;

T_2 outputs the lower eight bits of the two bytes for the delay time.

6) CRC check method

The CRC uses the standard CRC-32 polynomial:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

seed = 0xFFFFFFFF

See Appendix B for a list of table and table lookup function codes generated from this polynomial.

5.4 Self-check function and real-time output function of working status

The product has the functions of self-checking and real-time output of working status. The data frame contains a byte indicating the status, and the real-time output of product working status information is started after the power-on start is completed. The status bits are defined in Table 5-10.

Table 5-10 Product Status Bit Definitions

Bit	Definition
7	0 = normal, 1 = system-wide abnormal
6	0 = normal, 1 = starting
5	0 = normal, 1 = abnormal external environment
4	0 = normal, 1 = three axes out of service condition
3	0 = normal, 1 = error in three-axis output
2	0 = OK, 1 = Z axis out of use condition or error
1	0 = OK, 1 = Y axis out of use condition or error
0	0 = OK, 1 = X axis out of use condition or error

6 Functional testing

6.1 Test equipment and instrumentation required

The equipment and instruments required in the test include: DC regulated power supply, computer, turntable, test tooling and test cable.

6.2 Functional testing

The product is in a static state, and the DC regulated power supply is used to supply power to the product. The power supply requirements meet the requirements of 1.2.2. The specific connection mode of the product is shown in Figure 6-1. Data is received according to the communication protocol, and the angular velocity output of the product is received and displayed by the upper computer receiving software.

Rotate the gyroscope assembly in the positive direction around X, Y and Z respectively (if conditions permit, the turntable can be used for input, and if conditions do not permit, it can be rotated by hand), and the angular velocity output of the corresponding axis can be monitored as the positive angular rate. Rotate the product reversely around X, Y and Z respectively, and the angular velocity output of the corresponding axis can be monitored to be a negative angular velocity. It indicates that the angular velocity output polarity of the product is correct. The three angular rate values at the output of the product shall be in the vicinity of 0 deg/s under stationary conditions.

The acceleration output of the corresponding axis can be monitored to be 1G when X, Y and Z are respectively in the forward direction. Under static conditions, the acceleration at the output of two axes of the product is about 0 G, and the acceleration at the output of the third axis is about 1 G.

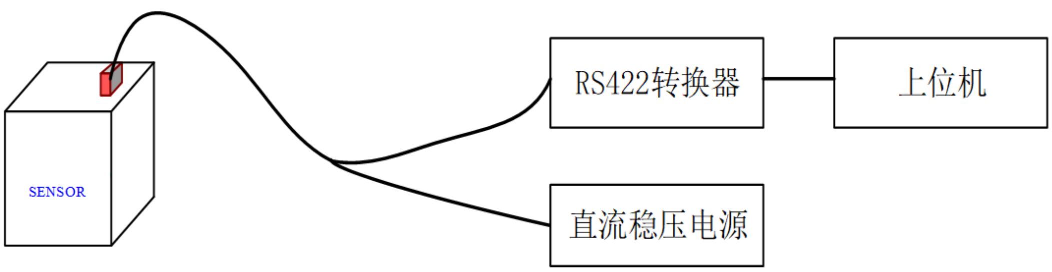

Figure 6-1 Inertial Measurement Unit Test Connection Diagram

7 Use 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 contains precision instruments. Knocking and falling are prohibited.

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

Diskette

CAD

BS-IU30-M-D6EC Inertial Measurement Unit Product Matching Table

Serial number	Name	Quantity	Unit	Remark
1	BS-IU30-M-D6EC product	1	Taiwan	
2	Product certificate	1	Share	
3	Instructions for use	1	Share	
4	Packing list	1	Share	
5	Product packing box	1	A	

Appendix B CRC Lookup Table and Lookup Function

Lookup table for B1 CRC32

```
static Uint32 crc_table[256]={
0x00000000, 0x04c11db7, 0x09823b6e, 0x0d4326d9, 0x130476dc, 0x17c56b6b, 0x1a864db2,
0x1e475005, 0x2608edb8, 0x22c9f00f, 0x2f8ad6d6, 0x2b4bcb61, 0x350c9b64, 0x31cd86d3,
0x3c8ea00a, 0x384fbdbd,0x4c11db70, 0x48d0c6c7, 0x4593e01e, 0x4152fda9, 0x5f15adac,
0x5bd4b01b, 0x569796c2, 0x52568b75, 0x6a1936c8, 0x6ed82b7f, 0x639b0da6, 0x675a1011,
0x791d4014, 0x7ddc5da3, 0x709f7b7a, 0x745e66cd,0x9823b6e0, 0x9ce2ab57, 0x91a18d8e,
0x95609039, 0x8b27c03c, 0x8fe6dd8b, 0x82a5fb52, 0x8664e6e5, 0xbe2b5b58, 0xbaea46ef,
0xb7a96036, 0xb3687d81, 0xad2f2d84, 0xa9ee3033, 0xa4ad16ea, 0xa06c0b5d,0xd4326d90,
0xd0f37027, 0xddb056fe, 0xd9714b49, 0xc7361b4c, 0xc3f706fb, 0xceb42022, 0xca753d95,
0xf23a8028, 0xf6fb9d9f, 0xfbb8bb46, 0xff79a6f1, 0xe13ef6f4, 0xe5ffeb43, 0xe8bccd9a,
0xec7dd02d,0x34867077, 0x30476dc0, 0x3d044b19, 0x39c556ae, 0x278206ab, 0x23431b1c,
0x2e003dc5, 0x2ac12072, 0x128e9dcf, 0x164f8078, 0x1b0ca6a1, 0x1fcdbb16, 0x018aeb13,
```

Tracing

Trace

Old base map

Base map

Diskette

CAD

```
0x054bf6a4, 0x0808d07d, 0x0cc9cdca,0x7897ab07, 0x7c56b6b0, 0x71159069, 0x75d48dde,
0x6b93dddb, 0x6f52c06c, 0x6211e6b5, 0x66d0fb02, 0x5e9f46bf, 0x5a5e5b08, 0x571d7dd1,
0x53dc6066, 0x4d9b3063, 0x495a2dd4, 0x44190b0d, 0x40d816ba,0xaca5c697, 0xa864db20,
0xa527fdf9, 0xa1e6e04e, 0xbfa1b04b, 0xbb60adfc, 0xb6238b25, 0xb2e29692, 0x8aad2b2f,
0x8e6c3698, 0x832f1041, 0x87ee0df6, 0x99a95df3, 0x9d684044, 0x902b669d, 0x94ea7b2a,
0xe0b41de7, 0xe4750050, 0xe9362689, 0xedf73b3e, 0xf3b06b3b, 0xf771768c, 0xfa325055,
0xfef34de2, 0xc6bcf05f, 0xc27dede8, 0xcf3ecb31, 0xcbffd686, 0xd5b88683, 0xd1799b34,
0xdc3abded, 0xd8fba05a,0x690ce0ee, 0x6dcdfd59, 0x608edb80, 0x644fc637, 0x7a089632,
0x7ec98b85, 0x738aad5c, 0x774bb0eb, 0x4f040d56, 0x4bc510e1, 0x46863638, 0x42472b8f,
0x5c007b8a, 0x58c1663d, 0x558240e4, 0x51435d53,0x251d3b9e, 0x21dc2629, 0x2c9f00f0,
0x285e1d47, 0x36194d42, 0x32d850f5, 0x3f9b762c, 0x3b5a6b9b, 0x0315d626, 0x07d4cb91,
0x0a97ed48, 0x0e56f0ff, 0x1011a0fa, 0x14d0bd4d, 0x19939b94, 0x1d528623,0xf12f560e,
0xf5ee4bb9, 0xf8ad6d60, 0xfc6c70d7, 0xe22b20d2, 0xe6ea3d65, 0xeba91bbc, 0xef68060b,
0xd727bbb6, 0xd3e6a601, 0xdea580d8, 0xda649d6f, 0xc423cd6a, 0xc0e2d0dd, 0xcda1f604,
0xc960ebb3,0xbd3e8d7e, 0xb9ff90c9, 0xb4bcb610, 0xb07daba7, 0xae3afba2, 0xaafbe615,
0xa7b8c0cc, 0xa379dd7b, 0x9b3660c6, 0x9ff77d71, 0x92b45ba8, 0x9675461f, 0x8832161a,
0x8cf30bad, 0x81b02d74, 0x857130c3,0x5d8a9099, 0x594b8d2e, 0x5408abf7, 0x50c9b640,
0x4e8ee645, 0x4a4ffbf2, 0x470cdd2b, 0x43cdc09c, 0x7b827d21, 0x7f436096, 0x7200464f,
0x76c15bf8, 0x68860bfd, 0x6c47164a, 0x61043093, 0x65c52d24,0x119b4be9, 0x155a565e,
0x18197087, 0x1cd86d30, 0x029f3d35, 0x065e2082, 0x0b1d065b, 0x0fdc1bec, 0x3793a651,
0x3352bbe6, 0x3e119d3f, 0x3ad08088, 0x2497d08d, 0x2056cd3a, 0x2d15ebe3,
0x29d4f654,0xc5a92679, 0xc1683bce, 0xcc2b1d17, 0xc8ea00a0, 0xd6ad50a5, 0xd26c4d12,
0xdf2f6bcb, 0xdbee767c, 0xe3a1cbc1, 0xe760d676, 0xea23f0af, 0xeee2ed18, 0xf0a5bd1d,
0xf464a0aa, 0xf9278673, 0xfde69bc4,0x89b8fd09, 0x8d79e0be, 0x803ac667, 0x84fbdbd0,
0x9abc8bd5, 0x9e7d9662, 0x933eb0bb, 0x97ffad0c, 0xafb010b1, 0xab710d06, 0xa6322bdf,
0xa2f33668, 0xbcb4666d, 0xb8757bda, 0xb5365d03, 0xb1f740b4
    };
```

B2 Table lookup function

```
void CRC32(Uint16 *pch,int len)
{
    UInt32 reg = 0xFFFFFFFF; //initial value
    int i;
    int res = 4 - len % 4;
    for( i = 0; i < len; i++)
    {
        reg = (reg<<8) ^ crc_table32[(((reg>>24)&0xFF) ^ pch[i])];
    }
    for (i = 0; i < res; i++)
    {
        reg = (reg << 8) ^ crc_table32[(((reg >> 24) & 0xFF) ^ 0x00)];
    }
```

```
        crc_data[0] = (byte)((reg>>24) & 0xFF);
        crc_data[1] = (byte)((reg>>16) & 0xFF);
        crc_data[2] = (byte)((reg>>8) & 0xFF);
        crc_data[3] = (byte)(reg & 0xFF);
        return;
}
```

Where, the CRC _ data [4] is the calculated CRC32 value.