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BS-IC21-1yx-D6EC

Inertial Measurement Unit User Manual

EX2.900.012SM

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Description

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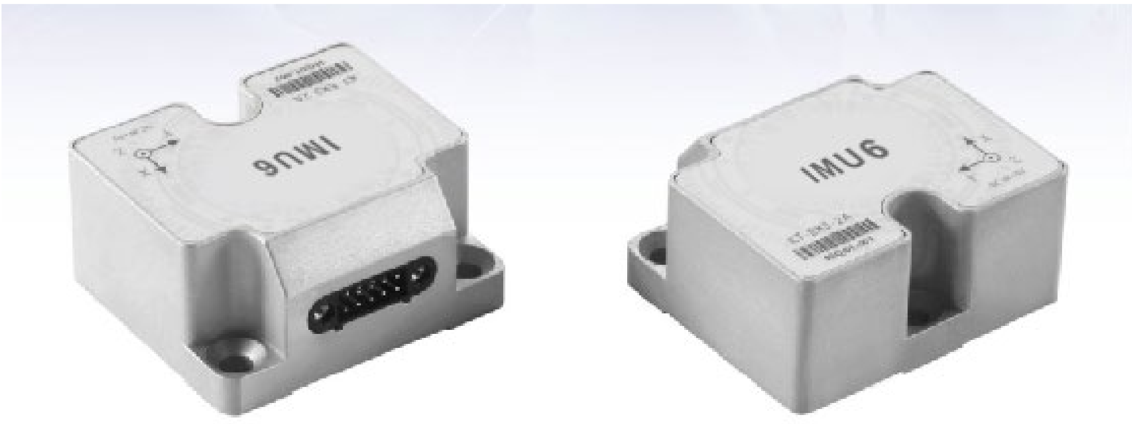
Old base map

Base map

This instruction manual is the main reference document for the use and operation of BS-IC21-1yx-D6EC and is mainly prepared in accordance with the Technical Agreement of BS-IC21-1yx-D6EC MEMS Inertial Measurement Unit and the Technical Conditions of KTJT-001 Inertial Measurement Unit and Triaxial Gyro Combination.

BS-IC21-1yx-D6EC series 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 consists of a three-axis gyroscope, a three-axis acceleration meter, a three-axis inclination angle, a temperature sensor, a signal processing board, a structure and necessary software, and is used for measuring three-axis angular rate, three-axis acceleration and three-axis inclination angle of a carrier. And output that gyro, the loading table and the inclination data 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.

All models available:
BS-IC21-11-D6EC
BS-IC21-1A1-D6EC
BS-IC21-12-D6EC
BS-IC21-1A2-D6EC

1.2 Main technical parameters

1.2.1 Gyroscope specifications

Parameter	Unit	BS-IC21-1-x	BS-IC21-1A-x

Measuring range (customizable)	°/s	±400	±400
Zero bias stability (@ Allan Variance)	°/h	1	0.5
Zero bias stability (1s smooth, 1σ, room temperature)	°/h	10	5
Zero bias stability (10s smooth, 1σ, room temperature)	°/h	5	1
Zero-bias error over full temperature range	°/h	20	10
Random walk	°/√h	0.2	0.1
Zero-bias repeatability	°/h	10	5
Zero bias acceleration sensitivity	°/h/g	1	1
Resolution	°/h	2	1
Scale factor nonlinearity	ppm	500	
Scale factor repeatability	ppm	500	
Cross coupling	%	0.1	
Bandwidth	Hz	125	

1.2.2 Add table technical indicators

Parameter	**Unit**	**IBS-IC21-1y-1**	**BS-IC21-1y-2**
Measuring range (customizable)	g	±10（80g optional)	±30（80g optional)
Zero-bias stability (Allan Variance @ 25 ℃)	mg	0.02	0.05
Zero-bias stability (1s smoothing)	mg	0.1	0.5
Zero-bias stability (10 s smoothing)	mg	0.05	0.2
Zero-bias error over full temperature range	mg	1	3
Random walk	m/s/√h	0.001	0.002
Zero-bias repeatability	mg	0.1	0.5
Scale factor repeatability	ppm	500	
Scale factor nonlinearity	ppm	500	
Bandwidth	Hz	125	

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1.2.3 Tilt angle specification (not configured by default, optional)

Parameter	Unit	BS-IC21-1y-x
Measuring range (customizable)	g	±1.7
Zero-bias stability (1s smoothing)	mg	0.5
Random walk	m/s/√h	0.08
Scale factor nonlinearity	ppm	100

1.2.4 Electrical characteristics

Parameter	Unit	BS-IC21-1y-x
Voltage	V	5
Power consumption	W	2
Ripple	mV	100

1.2.5 Environmental adaptability

Parameter	Unit	BS-IC21-1y-x
Operating temperature	℃	-45~85
Storage temperature	℃	-55~105
Vibration	--	10~2000Hz，6.06g
Impact	--	1000g,0.1ms

1.2.6 Other

Parameter	Unit	BS-IC21-1y-x
Weight	g	55±5

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 direction of the electrical connection interface, the Y axis points to the left side of the IMU, and the Z axis point to the top surface of the IMU, as shown in Figure 2-1.

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Old base map

Base map

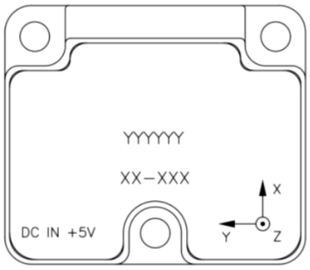

Figure 2-1 IMU Space Coordinate System

The installation of IMU should be matched with the axial direction of the coordinate system, otherwise the measured angular velocity data will be inaccurate. 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.

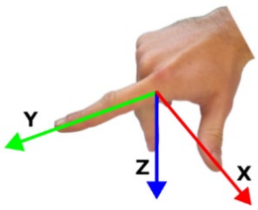

Figure 2-2 Right Hand Rule Principle 1

2.2 Right hand rule principle two

The three-degree-of-freedom gyroscope in the IMU 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.

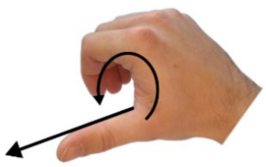

Figure 2-3 Right Hand Rule Principle 2

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3 Structural installation

See Figure 3-1 for outline drawing of BS-IC21-1yx-D6EC

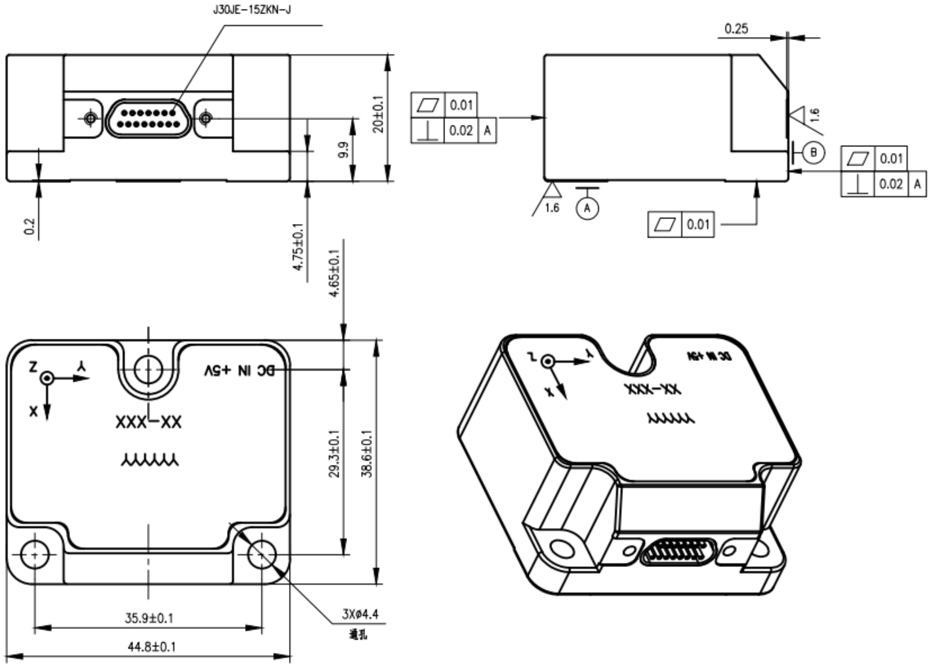

Fig. 3-1 Outline drawing of IMU

BS-IC21-1y-x is installed through 3 Φ4.4 through holes, and installed with 3 M4 screws (with spring washer and flat washer). When installing the connector, the plug shall be locked with the socket and the cable shall be fixed. In the figure○,A、○,BIs the installation datum plane of the inertia group.

It is recommended that the flatness of the mounting surface opposite to the reference surface shall not be greater than 0.01 mm, the verticality shall not be greater than 0.02 mm, and the surface roughness shall not exceed 0.8 μm.

4 Electrical characteristics

4.1 Electrical interface

The electrical connector model of BS-IC21-1yx-D6EC is J30JE-15-ZKN-J. See Table

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Old base map

Base map

4-1 and Figure 4-1 for the specific distribution of contacts.

Table 4-1 J30JE-15ZKN-J Contact Distribution

Contact number	Pin definition	Type	Explain
1	TxD-	OUTPUT	Product RS422 output interface negative terminal
2	RxD-	INPUT	Product RS422 receiving interface negative terminal
4	TOV	OUTPUT	Sync Signal(1)
5	NRST	INPUT	Reset signal(2)
8	VSUP	SUPPLY	Positive end of product power supply, DC regulated power supply
9	TxD+	OUTPUT	Product RS422 output interface positive terminal
10	RxD+	INPUT	Product RS422 receiving interface positive terminal
11	ExtTrig	INPUT	External Trigger Source(3)
12、13、15	GND	SUPPLY	Product ground, power ground and serial port ground
3、6~7、14	Reserved by the manufacturer	/	/

Notice

(1) The synchronization signal needs to be specially configured according to the requirements. The default IMU does not have this configuration and needs to be suspended.

(2) The reset signal needs to be specially configured as required. The default IMU does not have this configuration and needs to be suspended.

(3) The external trigger source needs to be specially configured according to the requirements. The default inertia group does not have this configuration and needs to be suspended.

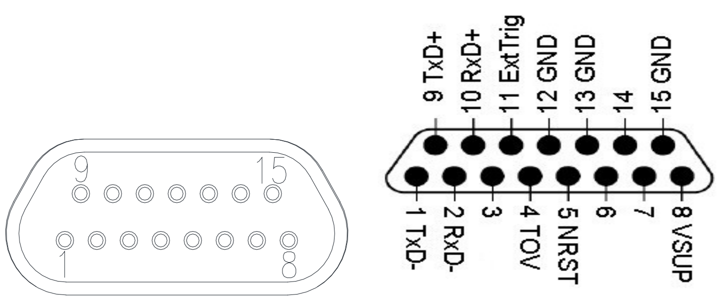

Fig. 4-1 Configuration Diagram of Connector Node (Seen from the Outside of the Product)

4.2 Electrical interface connections

The BS-IC21-1yx-D6EC is very simple to use. If no special additional functions are required, the IMU will send data through the RS422 communication interface protocol about 1 s after it is powered on. Figure 4-2 shows a simple interconnection diagram for the BS-IC21-1yx-D6EC.

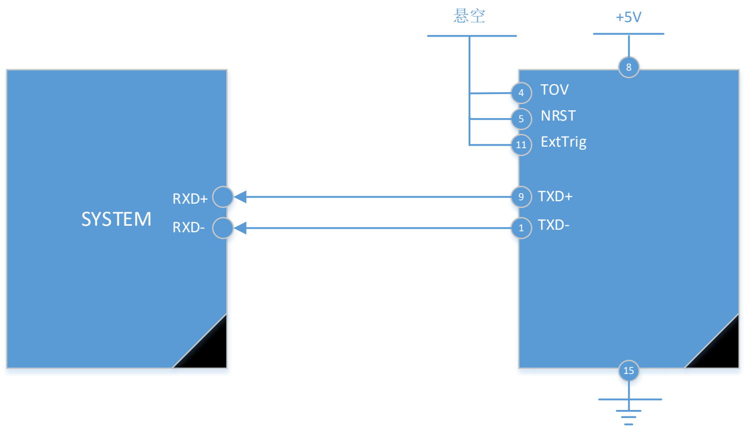

Fig. 4-2 Electrical connection 1

If all functions of BS-IC21-1yx-D6EC are to be used, interconnection wiring with IMU is required as shown in Figure 4-3.

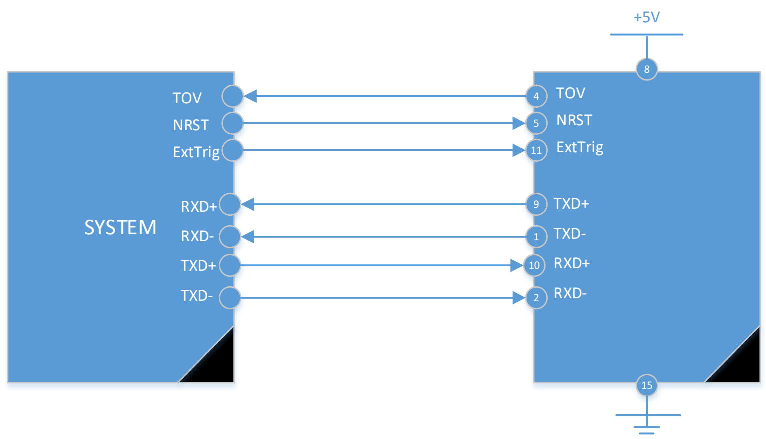

Figure 4-3 Electrical connection 2

4.3 Additional Function 1: Reset

The BS-IC21-1y-x has a separate digital input pin (NRST) that allows the BS-IC21-1y-x to be reset without re-powering up if the IMU has been configured for a particular configuration. The trigger mode of the NRST signal can be specially defined according to the requirements.

4.4 Additional function 2: external trigger

The BS-IC21-1y-xhas an independent digital input pin (ExtTrig). If the IMU has completed a specific configuration, when it receives an external trigger signal and generates an interrupt, it can send data through the RS422 communication interface protocol. The frequency of sending data is synchronized with the frequency of the ExtTrig signal. However, there are two special cases where sending data is not affected by an external trigger source:

a) In normal mode, send command 'C' to the IMU to test the RS422 interface. The IMU will transmit the configuration data stream independent of the external trigger source.

b) In the power-on initialization state, the IMU sends the initialization state data without being affected by the external trigger source.

Figure 4-4 is the timing diagram of the external trigger source sending data. The sampling frequency of the IMU is 1000Hz. The external trigger source shall not be higher than the sampling frequency. Latency is the trigger data sending delay.

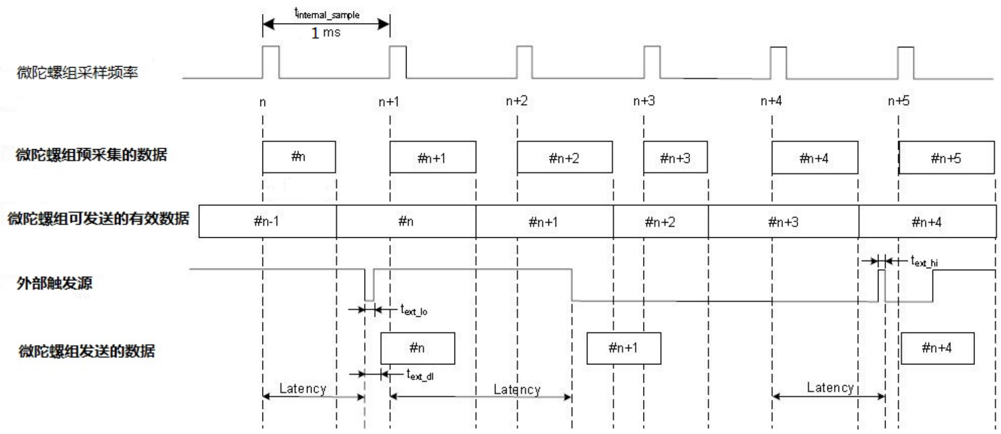

Figure 4-4 External Trigger Timing Diagram

4.5 Additional function 3: synchronization

The BS-IC21-1y-x has an independent digital output pin (TOV). If the IMU is configured specifically, it can output a signal of a specific frequency and provide a synchronization signal. Figure 4-5 shows the synchronization timing diagram without the external trigger source. Figure 4-6 shows the synchronization timing diagram with the external trigger source. The sampling frequency is 1000 Hz.

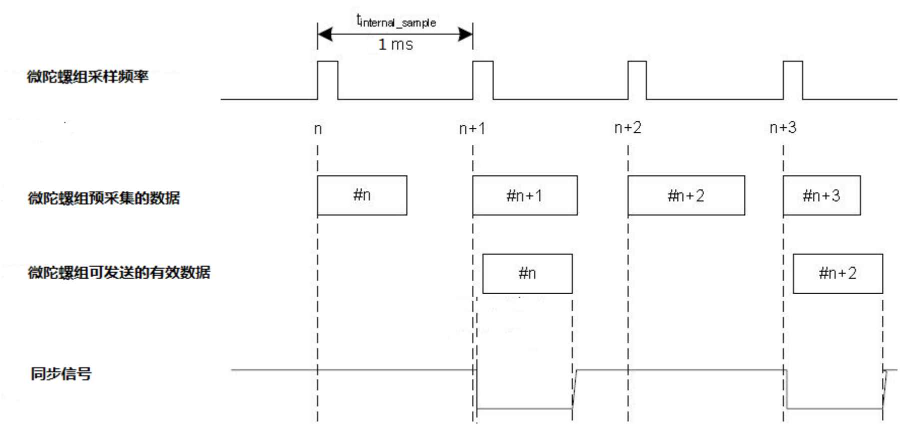

Figure 4-5 Synchronous Signal Timing 1

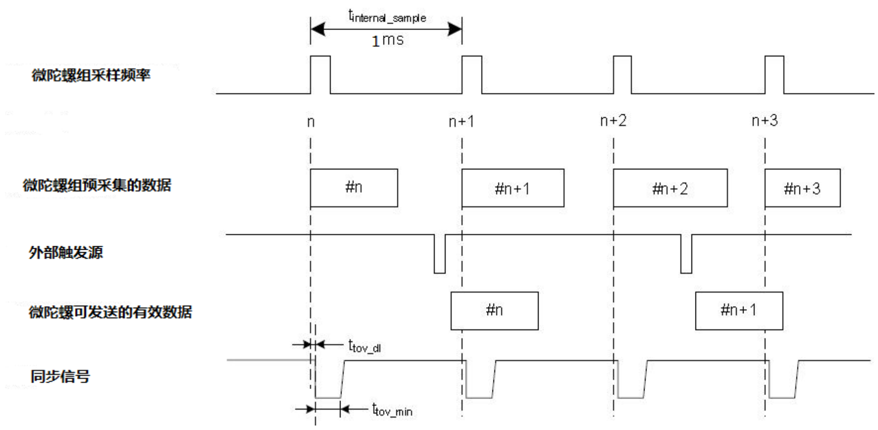

Figure 4-6 Synchronous Signal Timing 2

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 500Hz		Refer to Table 5-2 for data update rate restrictions.

	1000Hz	
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

Data frame is sent by IMU in each cycle, and 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	Valid range	Byte	Scale	Remark
1	Frame header	0x90	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular	[-400，400]	3	2^{-14}	Unit: (/s, from high to low, the most

	velocity	[-2000，2000]	3	2^{-12}	significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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	Valid range	Byte	Scale	Remark
1	Frame header	0x91	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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}	
		[-80，80]		2^{-16}	
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}	

		[-80，80]		2^{-16}	
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}	
		[-80，80]		2^{-16}	
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	Valid range	Byte	Scale	Remark
1	Frame header	0x92	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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	Valid range	Byte	Scale	Remark
1	Frame header	0x93	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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}	
		[-80，80]		2^{-16}	
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}	
		[-80，80]		2^{-16}	
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
		[-30，30]		2^{-18}	

		[-50，50]		2^{-17}	bit. See Note 2 for the specific algorithm.
		[-80，80]		2^{-16}	
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	Valid range	Byte	Scale	Remark
1	Frame header	0x94	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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	Valid range	Byte	Scale	Remark
1	Frame header	0xA5	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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}	
		[-80，80]		2^{-16}	

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}	
		[-80，80]		2^{-16}	
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}	
		[-80，80]		2^{-16}	
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

Diskette

CAD

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

Serial number	Parameter name	Valid range	Byte	Scale	Remark
1	Frame header	0xA6	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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.

Tracing

Trace

Old base map

Base map

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	Valid range	Byte	Scale	Remark
1	Frame header	0xA7	1	——	Packet header
2	X-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
3	Y-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
4	Z-axis angular velocity	[-400，400]	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.
		[-2000，2000]	3	2^{-12}	
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
		[-30，30]		2^{-18}	

		[-50，50]		2^{-17}	bit. See Note 2 for the specific algorithm.
		[-80，80]		2^{-16}	
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}	
		[-80，80]		2^{-16}	
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}	
		[-80，80]		2^{-16}	
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.

AR1								AR2								AR3							
Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16	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
2^9	2^8	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}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}

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

If the angular velocity range of the gyro is configured as ± 2000 °/s, the scale factor is 2^{12};

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, 50g, and 80g are tabulated for X = 19, 18, 17, and 16.

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 per 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.

T1								T2							
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 upper eight bits of 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

CRC checks all bytes from the data frame header to the check bit, using 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 begins 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 (input by the turntable if conditions permit, and rotate by hand if no conditions permit), and the angular velocity output of the corresponding axis can be monitored as the positive angular velocity. 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.

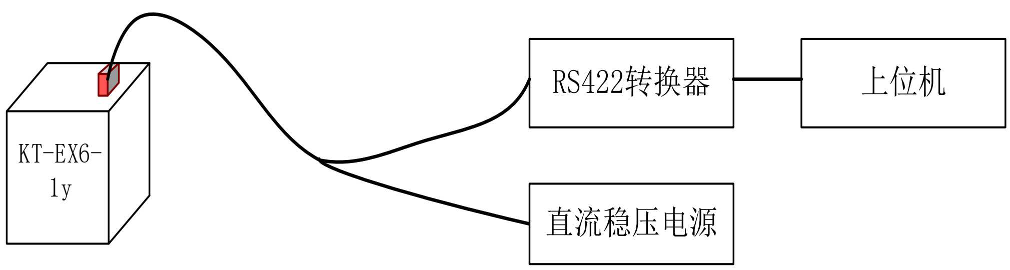

Fig. 6-1 Schematic diagram of IMU test connection

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

Product Matching Table of BS-IC21-1yx-D6EC Inertial Measurement Unit

Serial number	Name	Quantity	Unit	Remark
1	BS-IC21-1yx-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	

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,
```

Diskette

CAD

```
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,
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;
```

Tracing

Trace

Old base map

Base map

Mark | Change order | Signature,

```
        int Res=0; Remainder of//4
        if((len%4)!=0)
        {
            Res=4-len%4; //Need to supplement the number of 0 for calculating crc32
        }
       for( i = 0; i < len; i++)
        {
            reg = (reg<<8) ^ crc_table[(((reg>>24)&0xFF) ^ pch[i])];
        }
        for( i = 0; i < Res; I + +)//Extra 0 needs to be asked to participate in CRC
        {
            reg = (reg<<8) ^ crc_table[(((reg>>24)&0xFF) ^ 0x00)];
        }
        crc_data[0] = (reg>>24) & 0xFF;
        crc_data[1] = (reg>>16) & 0xFF;
        crc_data[2] = (reg>>8) & 0xFF;
        crc_data[3] = reg & 0xFF;
        return;
}
```

The CRC _ data [0] to the CRC _ data [3] is the calculated CRC32 value.

Appendix C Product Naming Rules

The product type spectrum is designed according to the standardization requirements, and the specific product type spectrum naming rules are as follows:

Diskette

CAD

BS-IC21-1yx-D6EC

D6EC:
Digital
6 axis
Encapsulated
Connected through
connector

BS - Blitz Sensor

x - accelerometer parameters
1 - +-10 g
2 - +-30 g

y - Gyroscope parameters
1 - +-400 deg/s, standard accuracy
1A - +-400 deg/s, higher accuracy

IC21 - Series

Tracing

Trace

Old base map

Base map

			BS-IC21-1yx-D6EC	EX2.900.012SM
Mark	Change order	Signature,	Page of 24 No. 29 Page	