BS-IC30C-M-D6EC
Inertial Measurement Unit
Instructions for use

February, 2023

1. Product overview

The BS-IC30C-M-D6EC is an inertial measurement unit (IMU) based on micromachining technology (MEMS), with built-in high-performance MEMS gyroscope and MEMS accelerometer, outputting 3 angular velocities and 3 accelerations.

BS-IC30C-M-D6EC features high reliability and strong environmental adaptability. By matching different software, the product can be widely used in tactical and industrial UAV, smart ammunition, seeker and other fields.

2. Product features

1) Three-axis digital gyroscope:
   a) ± 500°/s dynamic measuring range;
   b) Zero-bias stability: 3 °/H (GJB, 10s), 0.3 °/H (ALLAN);
2) Triaxial digital accelerometer:
   a) ± 16 G dynamic measuring range;
   b) Zero-bias stability: 0.1mg (GJB, 10S), 0.02mg (ALLAN);
3) High reliability: MTBF > 20000h;
4) Guaranteed accuracy within the full temperature range (-40 ℃ ~ 80 ℃): built-in high-performance temperature calibration and compensation algorithm;
5) Suitable for working under strong vibration conditions;
6) Interface 1-way RS422
7) Compatible with STIM300

3. Field of application

1) Tactical and Industrial UAV
2) Smart Munitions
3) Seeker

4. Product indicators

Table 1 Product performance index

Parameter		Test conditions	Design accuracy	Unit
Peg-top	Dynamic measuring range	-	±500	°/s
	Bias stability	Allan variance (500 °/s range, normal temperature)	0.3	°/h
		10 s average (-40 ℃ ~ + 80 ℃, constant temperature),	3.0	°/h
	Bias	Zero-bias range	0.1	°/s
		Zero-bias variation over full temperature range	0.01	°/s
		Start repeatability	0.005	°/s
		Ffect of linear acceleration on bias	0.002	°/s/g
		Influence of vibration on Bias, change before and after vibration	0.002	°/s/g
		Influence of vibration on Bias,	0.001	°/s/g

Parameter		Test conditions	Design accuracy	Unit
		change before and during vibration		
	Scale factor	Scale factor accuracy	0.1	%
		Scale factor nonlinearity	0.01	%FS
	Angular random walk	-	0.06	°/√hr
	Bandwidth	-	200	Hz
Accelerometer	Dynamic measuring range	-	16	g
	Bias stability	Allan variance (16g range, normal temperature)	0.02	mg
		10 s average (-40 ℃ ~ + 80 ℃, constant temperature)	0.03	mg
	Bias	Zero-bias range	1	mg
		Zero-bias variation over full temperature range	1	mg
		Start repeatability	0.2	mg
	Scale factor	Scale factor accuracy	0.3	%
		Scale factor nonlinearity	0.02	%FS
	Speed random walk	-	0.08	m/s/√hr
	Bandwidth	-	200	Hz
Communication interface	1-way SR422	Baud rate	460.8	MHz
	Sampling frequency	UART	1000	Hz
Electrical characteristics	Voltage	-	5	V
	Power consumption	-	1.5	W
	Ripple	P-P	150	mV
Structural characteristics	Size	-	38.6×44.6×21.5	mm
	Weight	-	65±2	g
Use environment	Operating temperature	-	-40~80	℃
	Storage temperature	-	-45~85	℃
	Vibration	-	20~2000Hz，6.06g	
	Impact	-	6000g，0.5ms	
Reliability	MTBF	-	20000	h
	Continuous working time	-	120	h

5. Electrical interface

The electrical connector of BS-IC30C-M-D6EC product is J30J-15 TJL, and the specific contact definition and allocation are shown in the following table:

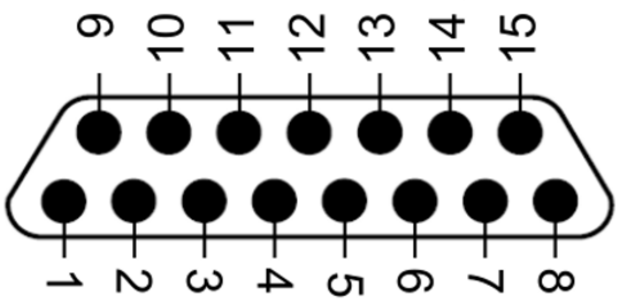

Figure 1 Connector node configuration

Table 2 3 J0J-15 TJL Connector Contact Definition Allocation Table

Stitch number	Name	Type	Remark
1	TxD-	Output	RS422
2	RxD-	Input	RS422
3	TST_1	Output	
4	TOV_1	Output	
5	RST	Input	
6	GND	Input	
7	Spare		
8	VCC_5V	Power source	+5v
9	TxD+	Output	RS422
10	RxD+	Input	RS422
11	ExtTrig	Input	Synchronous input 5V
12	GND	Input	
13	GND	Input	
14	Spare		
15	GND	Power ground	

6. Fabric interface

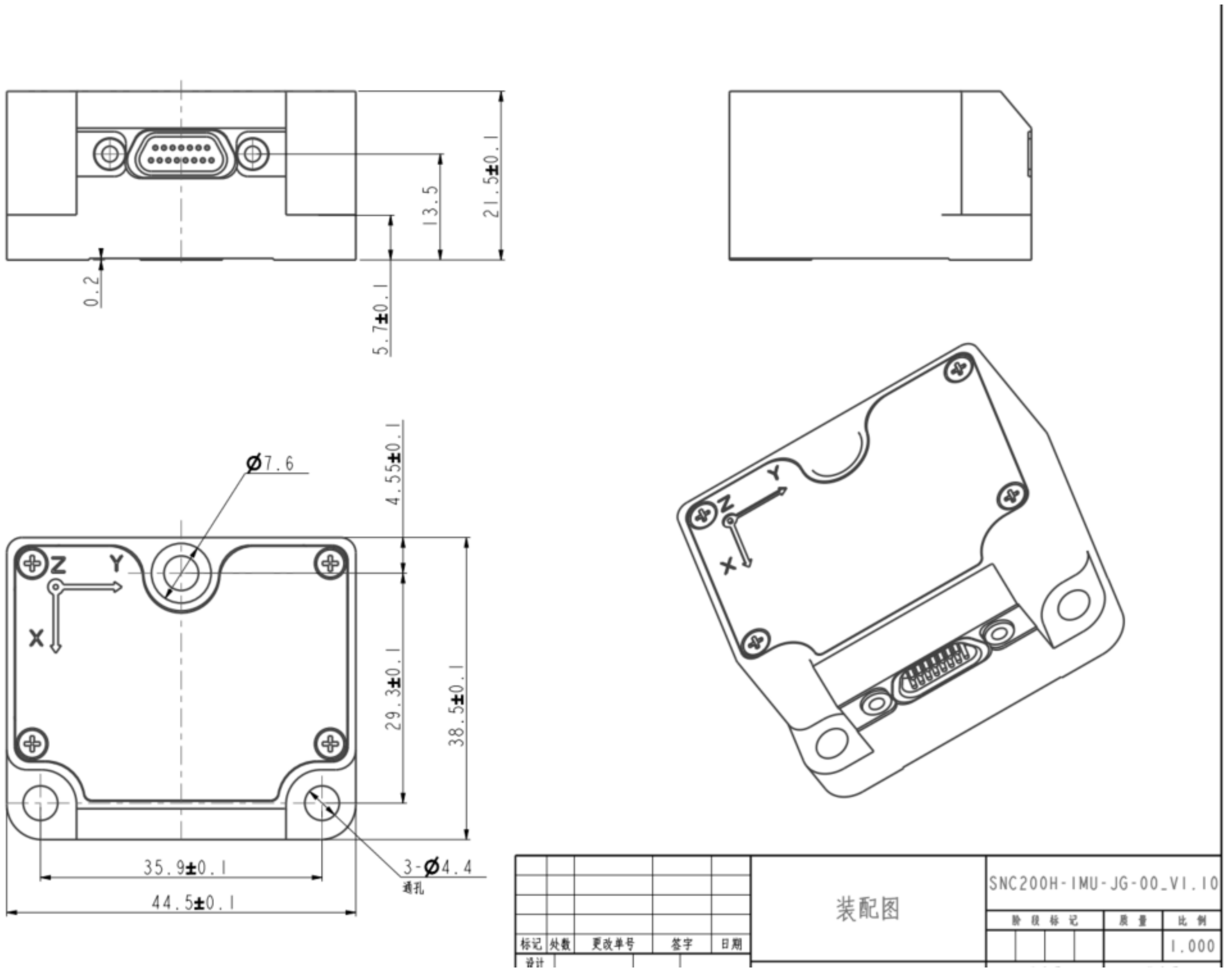

Figure 2Schematic diagram of structure outline

7. Instructions for use

7.1. UART reads and writes data

7.1.1. Configurable parameters

The communication protocol, baud rate, sampling frequency and output frequency of the product can be modified by sending user instructions through the upper computer. The configurable parameters are shown in the following table:

Table 3Configurable parameter table

Parameter	Configuration	Explain
Data frame	Gyro (Frame ID = 0x90) Gyro + Add Table (Frame ID = 0x91) Gyro + Temperature (Frame ID = 0x94) Gyro + plus meter + temperature (frame ID = 0 xA5)	
Data update rate	1000Hz	Switch the data update rate by sending

	500Hz 200Hz 100Hz 50Hz	a command. Refer to Table 11 for switching.
Peg-top	Range: 500 DPS ODR：1000Hz Bandwidth: 200Hz	Angular rate (°/s)
Add a table	Range: 16g/80g ODR：1000Hz Bandwidth: 200Hz	Acceleration (G)
DATAGRAM	Angular velocity, acceleration, temperature (℃)	
DATAGARM TERMINATION	NPNE <CR><LF>	
RS422 baud rate	921600 bits/s 460800 bits/s 374400 bits/s 256000 bits/s 230400 bits/s	Configure different baud rates according to the data frame length of different communication protocols. Refer to Table 4 for the maximum baud rate. Refer to Table 11 for the user instruction of switching baud rate.
RS422 check digit	None (no check) Odd (odd parity) Even (even check)	
RS422 data stop bit	1 1.5 2	

7.1.2. Communication interface

Standard RS-422 serial communication is used. The transmission baud rate, data update rate and transmission baud rate can be modified through the user command sent by the upper computer. The following table shows the maximum data update rate corresponding to different data frame contents.

When there is no special configuration, the default state of the product is: baud rate 921 600bps, 8 data bits, 1stop bit, no check bit, data frame ID is 0 xA5, and update rate is 1000Hz.

Table 4 Maximum data update ratio

Frame content	Frame length	230400 bit/s	256000 bit/s	374400 bit/s	460800 bit/s	921600 bit/s
Angular velocity	18	1000Hz	1000Hz	1000Hz	1000Hz	1000Hz
Angular velocity + acceleration	28	500Hz	500Hz	1000Hz	1000Hz	1000Hz

Angular velocity + temperature	25	500Hz	1000Hz	1000Hz	1000Hz	1000Hz
Angular velocity + acceleration + temperature	42	500Hz	500Hz	500Hz	1000Hz	1000Hz

Note:

1. Frame length does not include < CR > < LF >
2. 10 bits/byte(=1 start bit,8 data bits,no parity bit,1 stop bit)

7.1.3. Protocol format

Different communication protocol formats can be changed by configuring different frame IDs. The specific communication protocol formats are shown in the following table:

Table 5'Angular Velocity + acceleration + temperature (frame ID = 0xA5) 'protocol format

Serial number	Parameter name	Valid range	Byte	Scale	Remark
1	Frame header	0xA5	1	——	Packet header
2	X-axis angular velocity	[-500，500]	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	[-500，500]	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	[-500，500]	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 10 for specific definitions.
6	X-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	
7	Y-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	
8	Z-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	

9	Add table status	——	1	——	All zeros are normal. See Table 10 for specific definitions.
10	X-axis gyro temperature	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
11	Y-axis gyro temperature	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
12	Temperature of Z-axis gyroscope	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
13	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 10 for specific definitions.
14	X-axis plus surface temperature	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
15	Y-axis plus surface temperature	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
16	Z-axis plus surface temperature	[-40，+85]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
17	Add thermometer status	——	1	——	All zeros are normal. See Table 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 4 for the specific algorithm.
20	CRC32	——	4	——	CRC32 verification, see instruction 5

Table 6 Angular velocity (frame ID = 0x90) 'protocol format

Serial number	Parameter name	Valid range	Byte	Scale	Remark
1	Frame header	0x90	1	——	Packet header
2	X-axis angular velocity	[-500，500]	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	[-500，500]	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	[-500，500]	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 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 4 for the specific algorithm.
8	CRC32	——	4	——	CRC32 verification, see instruction 5

Table 7Angular Velocity + Acceleration (Frame ID = 0x91) 'protocol format

Serial number	Parameter name	Valid range	Byte	Scale	Remark
1	Frame header	0x91	1	——	Packet header
2	X-axis angular velocity	[-500，500]	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	[-500，500]	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	[-500，500]	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 10 for specific definitions.
6	X-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	
7	Y-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	
8	Z-axis acceleration	[-16，16]	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.
		[-80，80]		2^{-16}	

9	Add table status	——	1	——	All zeros are normal. See Table 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 4 for the specific algorithm.
12	CRC32	——	4	——	CRC32 verification, see instruction 5

Table 8Angular Velocity + Temperature (Frame ID = 0x94) 'protocol format

Serial number	Parameter name	Valid range	Byte	Scale	Remark
1	Frame header	0x94	1	——	Packet header
2	X-axis angular velocity	[-500，500]	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	[-500，500]	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	[-500，500]	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 10 for specific definitions.
6	X-axis gyro temperature	[-40，+85]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
7	Y-axis gyro temperature	[-40，+85]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.
8	Temperature of Z-axis gyroscope	[-40，+85]	2	2^{-8}	Unit: ℃, from high to low, the most significant bit of the first byte is the sign bit. See Note 3 for the specific algorithm.

9	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 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 4 for the specific algorithm.
12	CRC32	——	4	——	CRC32 verification, see instruction 5

Explain

1) Gyro angular velocity output [°/s] = $\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^{14}}$, the data bit format is shown in Figure 3;

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.

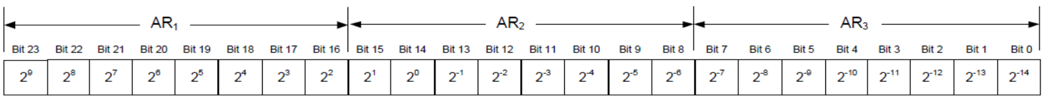

Figure 3Convert gyro angular velocity output to [°/s]

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

AmongAR_1Outputs the upper eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_2Outputs the middle eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_3Outputs the lower eight bits of the three bytes for the angular velocity of each axis of the accelerometer.

X is the scale index of the addition table, and the addition tables of 16 G and 80 G correspond to X of 18 and 16.

3) Temperature output [°C] = $\frac{T_1 \cdot 2^8 + T_2}{2^8}$ The data bit format is shown in Figure 4.

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.

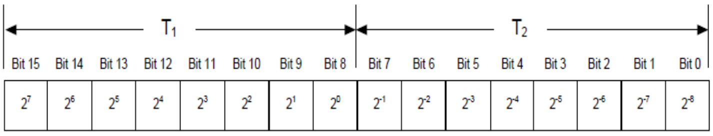

Figure 4Convert temperature output to [°C]

4) 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_2outputs the lower eight bits of the two bytes for the delay time.

5) 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

The number of virtual bytes added for the CRC calculation is shown in the following table:

Table 9Number of virtual bytes added for CRC calculation

Serial number	Frame content	Frame ID	Number of virtual bytes
1	Angular velocity	0x90	2
2	Angular velocity + acceleration	0x91	0
3	Angular velocity + temperature	0x94	3
4	Angular velocity + acceleration + temperature	0xA5	2

7.1.4. 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 the table.

Table 10Product status bit definition

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

7.1.5. Configuration commands

The upper computer sends different user commands to switch the output baud rate and data update rate of the product, as shown in the following table:

Table 11 Configure user directives

Serial number	User command	Explain	Remark
1	$GPENB	Enable UART power-on automatic output	
2	$GPDIS	Close UART power-on automatic output	
3	$GPSER	View serial number and configuration information	
4	$GPCOM1	Configure the output baud rate as 230400 bit/s	
5	$GPCOM2	Configure the output baud rate as 256000 bit/s	
6	$GPCOM3	Configure the output baud rate as 374400 bit/s	
7	$GPCOM4	Configure the output baud rate as 460800 bit/s	
8	$GPCOM9	Configure the output baud rate as 921600 bit/s	
9	$GPRATIO 1	Data update rate is configured as 1000Hz	
10	$GPRATIO 2	Data update rate is configured as 500Hz	
11	$GPRATIO 5	Data update rate is configured as 200Hz	
12	$GPRATIO 10	Data update rate is configured as 100Hz	
13	$GPRATIO 20	Data update rate is configured as 50Hz	
14	$SETTCP 1	Content of switching communication protocol frame: gyro (frame ID = 0x90)	
15	$SETTCP 2	Content of switching communication protocol frame: gyro + table addition (frame ID = 0x91)	
16	$SETTCP 3	Content of switching communication protocol frame: gyro + temperature (frame ID = 0x94)	
17	$SETTCP 4	Content of switching communication protocol frame: gyro + meter + temperature (frame ID = 0xA5)	
18	$SETRANGE 1	The range of the switchover meter is 16g.	
19	$SETRANGE 2	Switchover plus meter range is 80 G	