
Inertial Navigation System with GPS BS-IC24G-M-D6EC User Manual

1. Product introduction:

Inertial navigation system BS-IC24G-M-D6EC is a domestic inertial measurement device with high performance, small size and high overload resistance. The gyro bias stability is $1.2^{\circ}/H$ (Allan), and the accelerometer bias stability is $50\text{ }\mu\text{g}$ (Allan). It can be used for precise navigation, control and dynamic measurement of weapons. This series of products adopt high-precision MEMS inertial devices, which have high reliability and high robustness, and can accurately measure the angular velocity and acceleration information of moving carriers in harsh environments.

Inertial navigation system BS-IC24G-M-D6EC has a built-in GPS/BD single-frequency dual-mode satellite receiver, a three-axis magnetic sensor, and an integrated barometric sensor, which can realize altitude measurement. The working mode can be switched flexibly in the state of integrated navigation, AHRS, vertical gyroscope, etc. Can meet the application requirements of various combined navigation, and is particularly suitable for the navigation and control of various moving objects such as unmanned aerial vehicles, vehicle-mounted navigation, water surface vehicles and the like.

This product is equipped with a new integrated navigation fusion algorithm with independent intellectual property rights, which can achieve high-sensitivity tracking, accurate positioning in open space, and also meet the navigation applications of cities, deep forests, canyons and other terrains. The system has been carefully designed to reduce the size of the system with excellent integrated navigation performance to an unprecedented compact size and achieve mass minimization.

2. Composition and function

Inertial navigation system BS-IC24G-M-D6EC with built-in three-axis gyroscope and three-axis accelerometer is used to measure the three-axis angular rate and three-axis acceleration of the carrier. And output that gyro and table adding data subject to error compensation (including temperature compensation, installation misalignment angle compensation, nonlinear compensation and the like) through a serial port according to an agreed communication protocol.

The Inertial navigation system BS-IC24G-M-D6EC is based on inertial measurement unit, three-axis

magnetic sensor, atmospheric pressure sensor, satellite receiver, and built-in integrated navigation fusion algorithm. The fused attitude, heading, speed, altitude, position, clock and other information are output.

3. Product features:

- ※High Precision MEMS Inertial Navigation ※GPS/BD Dual Mode
- ※Integrated navigation, AHRS, vertical gyro and other working modes
- ※Support dynamic fast alignment ※High bandwidth, 400Hz data update rate
- ※External interface: 1-channel SPI and 1-channel UART
- ※Support multiple external sensor combinations (odometer/DVL)
- ※Small size, light weight ※Strong and reliable
- ※Fully compatible with a foreign 10-Dof inertial navigation system

4. Field of application:

Space-based domain / Unmanned aerial vehicle / Aerial photography / Photoelectric detection is stable / Land-based domain / Car navigation / Vehicle-mounted satellite communication / Track inspection of high-speed railway / Sea-based field / Channel detection / Shipborne positioning communication / Unmanned surface vehicle

5. Main technical indicators

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Gyroscope	Measuring range		±400	±450	—	deg/s
	Zero bias stability	Allan variance	—	1.8	—	deg /h
	Random walk		—	0.1	—	deg /√h
	Zero-bias repeatability	Full temperature range -40°C ≤ TA ≤ +85°C		0.1	0.2	deg/s
	Scale factor repeatability	Full temperature range -40°C ≤ TA ≤ +85°C		0.5	1	%
	Scale factor nonlinearity	FS=450 °/s		0.1	0.2	%FS
	Bandwidth				400	Hz
Accelerometer	Range			±5	±10	g
	Zero bias stability			0.1		mg
	Random walk			0.02	0.02	m/s/√h
	Zero-bias repeatability	Full temperature range -40°C ≤ TA ≤ +85°C		5	10	mg
	Scale factor repeatability	Full temperature range -40°C ≤ TA ≤ +85°C		0.5	1	%
	Scale factor nonlinearity			0.1 FS=5g	0.2 FS=10g	%FS
	Bandwidth				200	Hz 3dB
Magnet	Dynamic			±2		gauss

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Compass	measuring range					
	Resolution			120		uGauss
	Noise density			50		uGauss
	Bandwidth			200		Hz
Barometer	Pressure range		450		1100	mbar
	Resolution			0.1		mbar
	Absolute measurement accuracy			1.5		mbar
Externally based GNSS Inertial satellite integrated navigation Precision	Heading accuracy	Single GNSS, Maneuver Required, RMS		1.0		°
	Pitch and roll accuracy	GNSS Valid, RMS		0.3		°
		GNSS invalid, unlimited time, RMS		2		°
	Position accuracy	GNSS Valid, Single Point L1/L2, RMS		1.2		m
Communication interface	Speed accuracy	GNSS Valid, Single Point L1/L2, RMS		0.15		m/s
	1-way SPI	Baud rate			15	MHz
Electrical characteristics	1-way UART	Baud rate	9.6	230.4	921.6	Kbps
	Voltage		3.0	3.3	3.6	V
	Power consumption				1.5	W
Structural characteristics	Ripple	P-P			100	mV
	Size			44×47×14		mm
Use environment	Weight					g
	Operating temperature		-40		75	℃
	Storage temperature		-45		85	℃
	Vibration			10~2000Hz , 3g		
	Impact			30g, 11ms		
	Overload	(Half-sine 0.5msec)		1000		
Reliability	MTBF			20000		h
	Continuous working time			120		h

6. definition of coordinate

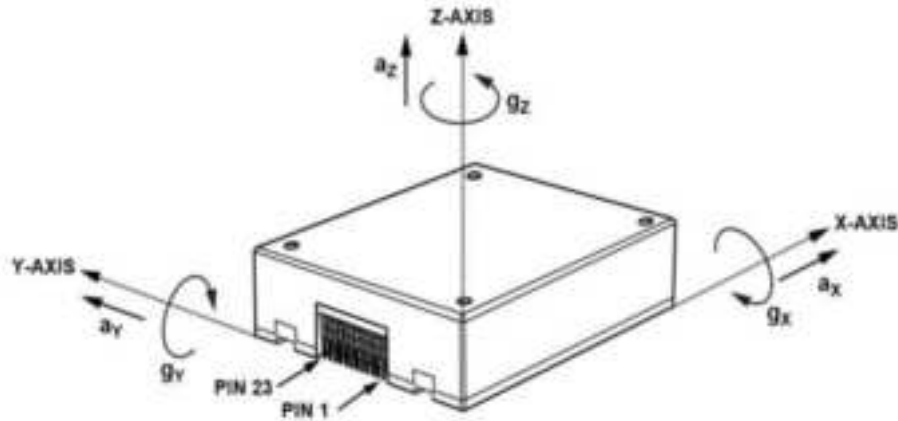
system 6.1 IMU polarity

definition

3 gyros (g_x , g_y , g_z) and 3 accelerometers (a_x , a_y , a_z) is defined as shown in the figure below, and the direction of the arrow is positive.



BS-IC24G-M-D6EC



Definition of 6.2 course angle, pitch angle and roll angle

Definition of course angle: Z axis is taken as the rotation axis, anticlockwise is positive, north is zero, and the range is $[-180^\circ, 180^\circ]$;

Definition of pitch angle: with X axis as the rotation axis, anticlockwise is positive, horizontal is zero, and the range is $[-90^\circ, 90^\circ]$;

Definition of roll angle: Y axis is the rotation axis, anticlockwise is positive, horizontal is zero, and the range is $[-180^\circ, 180^\circ]$.

7. Communication protocol

Special attention:

1. In order to achieve better performance, it is recommended that users first warm up for 15 minutes, then power off, and then power on again for two minutes.

In use, it is necessary to ensure that the carrier does not vibrate when it is powered on again.

2. The user performs a magnetic field calibration after each installation of the product and after the magnetic field environment has changed.

User communication protocol:

7.1 Debug Version Protocol

The baud rate is 460800 bps, the data bit is 8 bits, the stop bit is 1 bit, there is no check bit, the high byte is in the front and the low byte is in the back.

Course definition: positive to the east of north and negative to the west, ranging from -180 to 180 degrees. Coordinate system definition: right front top (northeast sky).

Number of bytes	Name	Byte	Zoom	Range	Unit	Description
1~2	Frame header	U,2				0xAA 71
3~4	measuretype					High 2 bytes of measurement correction type
5~13	Gyro	S,3*3	1e-3	±8388.608	°/s	X/y/Z Front Right Top
14~22	Add Acc	S,3*3	1e-5	±83.88608	g	X/y/Z Front Right Top
23~28	Magn	S,3*2	1e-2	±327.68	uT	X/y/Z Front Right Top
29~31	Hbar	U,1*3	1e-2	±83886.08	m	Barometer
32	flag	U,1				Bit1 -- Magnetic Valid Flag 1 -- Valid Bit2 -- Valid air pressure flag 1 -- Valid Bit3 -- GPS _ exist GPS information available 1 -- GPS information available Bit4-GPS measurement type flagGPS 1-valid Bit5 ~ 8 zero padding
33~36	Att attitude	S,2*2	1e-2	±327.68	°	Ptich ±90° Roll ±180°
37~38		U,1*2		655.36		Yaw ± 180 degrees, positive west of north, positive east of north.
39~47	Vn velocity	S,3*3	1e-4	±838.8608	m/s	Vel_E/N/U
48~58	Pos position	S,2*4	1e-7	±214.7483648	°	Longitude Lon/Latitude Lat with an accuracy of 0.01 m
		S,1*3	1e-2	±83886.08	m	Elevation

59	GPS_status	U,1				Bit1 ~ 4-Number of GPS positioning satellites (Max. 15)
60~61	measuretype	U,1				Lower 2 bytes of measurement correction type
62	Scenes and modes	U,1				Bit 1 ~ 4-working mode ALIGN = 1 INS = 2 AHRS= 3 VG= 4 Bit5 ~ 8--Work Scenario 1 = Vehicular 2 = Indoor 3 = Shipborne 4 = Fixed-wing 5 = Rotor 6 -- Helicopter
63						Bit5-8: system reserved word count Bit 4: padding zero. Bit1-3: 1st byte of IMU timestamp (highest)
64~67	IMU timestamp [2-4]	U,4				2nd to 5th bytes of IMU timestamp
68~71	System reserved word					
72~73	Temperature	S,2	1e-2	±327.68	℃	
74	Flag bit					Bit1 --flagVG2MC shake and sideslip switching flag 0 --VG 1 --MC Bit2--overRange overrange flare Bit3 ~ 4 -- initflagYaw heading initialization measurement flag 0 -- not initialized 1 -- already initialized 2 -- (out-of-range) heading not measured 3 -- re-initialization of heading after out-of-range Bit5 -- flag KfEnable filter enable flag 1 -- filter 0 -- pure inertia Bit6 ~ 7 -- initflagPV initialization velocity position mark 0 -- not initialized 1 -- barometric pressure initialization altitude 2 -- GPS initialization velocity position 3 -- GPS re-initialization velocity position after ejection Bit8 -- flagZUPT Quiet flag 1 -- Quiet
75	Check					Cumulative sum of all characters before check digit

The contents of the reserved words of the system are as follows, mainly GPS data, which are sent through 14

Number of cycles	Name	Byte	Zoom	Range	Unit	Description
1	GPS time stamp	U,4		4294967296	ms	
2	GPS_velE	S,4*1	1e-3	±2147483.648	m/s	Eastbound speed
3	GPS_velN	S,4*1	1e-3	±2147483.648	m/s	Northbound speed
4	GPS_velU	S,4*1	1e-3	±2147483.648	m/s	Celestial speed
5	GPS_Lon	S,4*1	1e-7	±214.7483648	Degree	Longitude Lon, with an accuracy of 0.01 m
6	GPS_Lan	S,4*1	1e-7	±214.7483648	Degree	Latitude Lan, with an accuracy of 0.01 m
7	GPS_hMSL	S,4*1	1e-3	±2147483.648	m	Elevation
8	GPS_headMot	S,4*1	1e-5	±21474.83648	Degree	Heading, ± 180 degrees, positive west of north, positive east of north.
9	hAcc	U,4*1	1e-3	4294967.296	mm	Horizontal accuracy estimation
10	vAcc	U,4*1	1e-3	4294967.296	mm	Vertical accuracy estimation
11	headAcc	U,4*1	1e-5	42949.67296	Degree	Heading accuracy estimation
12	sAcc	U,4*1	1e-3	4294967.296	mm/s	Velocity accuracy estimation
13	gSpeed	I,4	1e-3		mm/s	Ground speed
14	GPS_PDop	U,2	1e-2			
	Fill zero					
15	GPS_DELAY	U,4	1E-3		Seco nds	The current simulation does not use GPS delay.

Parameter setting:

When the product is powered on, it is in the default state of "number of consecutive transmissions". To set the parameters, the command of "stop output" must be sent first.

Note: After the following command is used, the user must be powered on and restarted to automatically switch to the state of continuous number of rounds.

Default setting: Baud rate: 460800bps, output frequency: 400hz, working scene: vehicle- mounted, magnetic enable on, magnetic declination: 0-degree, customer magnetic field calibration parameters are cleared

8. Caution:

- 1)The navigation system is a precision electronic product. When using it, pay attention to dust-proof, moisture-proof and mildew-proof. Handle it with care to avoid strong impact and vibration.
- 2)Although the metal shell is used, the module is not waterproof, so it must be avoided to use or soak in the rain.
- 3)Please check the connector before use to avoid loosening; Data power cables should be checked regularly to prevent kinking. After all cables of the equipment are connected, the equipment can be powered on and started, and it is strictly prohibited to plug and unplug the interface equipment with electricity;
- 4)Navigation module input voltage normal range (10 ~ 32 VDC), avoid overvoltage operation;
- 5)Note that the working environment of the receiver should be far away from high-power electromagnetic transmitting equipment and microwave transmitting equipment in the frequency band of 1.5 G that will interfere with the operation of GNSS;
- 6)The factory test pins are strictly prohibited for customer use.

9. Transportation and storage:

- 1)During transportation, the product shall be protected from direct rain and snow, prolonged exposure to the sun, contact with corrosive gases and mechanical damage. The product shall be handled with care during handling.
- 2)Dampness, impact and collision shall be avoided during transportation and storage to prevent human and mechanical damage during transportation. During transportation and storage, the outer packing box shall be kept dry, clean and pollution-free;
- 3)The ambient temperature of the warehouse for long-term storage of products is $20 \pm 10^{\circ}\text{C}$, and the relative humidity is not more than 80%. The warehouse shall be free of acid, alkali and corrosive gas, and free of strong mechanical vibration, impact and strong magnetic field.