Inertial Measurement Unit

BS-IC24B1-M-D6EC

User Manual

1. Product introduction:

BS-IC24B1-M-D6EC is a domestic inertial measurement unit with high performance, small size and high overload resistance. The gyro bias stability is 1°/h (Allan) and the accelerometer bias stability is 30 μg (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.

The inertial measurement unit 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 measurement unit BS-IC24B1-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 integrated navigation system BS-IC24B1-M-D6EC is based on the 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 Measurement Unit

※ AHRS\INS\IMU\ modes optional

※ Support dynamic fast alignment

※ High bandwidth

※ External interface: 1-channel SPI

※ Support multiple external sensor combinations (odometer/DVL)

※ Small size, light weight

※ Strong and reliable

※ Fully compatible with a foreign 10-Dof inertial measurement system




Space-based domain	Unmanned aerial vehicle	Aerial photography	Agricultural plant protection	Photoelectric detection is stable
Land-based domain	Car navigation	Vehicle-mounted satellite communication	Forest and land monitoring	Track inspection of high-speed railway
Sea-based field	Hydrographic survey	Channel detection	Shipborne positioning communication	Unmanned surface vehicle

4. Field of application:

5. Main technical indicators

Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Gyroscope	Measuring range		±400	±450	—	deg/s
	Bias stability	Allan variance	—	1	—	deg /h
	Random walk		—	0.1	—	deg /√h
	Bias repeatability			4		deg/h
	Scale factor nonlinearity			100		ppm
	Bandwidth			200		Hz
Accelerometer	Measuring range			±16		g
	Bias stability			0.03	0.045	mg
	Random walk			0.01	0.02	m/s/√h
	Bias repeatability			0.06		mg
	Scale factor nonlinearity			100		ppm
	Bandwidth(-3dB)			200		Hz
Magnetometer	Dynamic measuring range		±2			Gauss
	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
Communication interface	1-way SPI	Baud rate		10	20	MHz
	Sampling Rate	SPI		2000		Hz

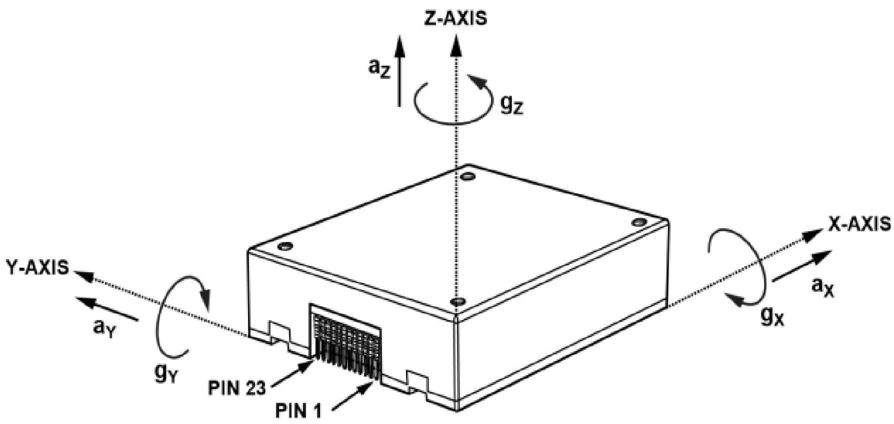
Parameter		Test conditions	Minimum value	Typical value	Maximum value	Unit
Electrical characteristics	Voltage		3.0	3.3	3.6	V
	Power consumption				1.5	W
	Ripple	P-P			100	mV
Structural characteristics	Size			44×47×14		mm
	Weight			50		g
Use environment	Operating temperature		-40		85	℃
	Storage temperature		-45		105	℃
	Vibration			10~2000Hz，3g		
	Impact			30g， 11ms		
	Overload	(Half-sine 0.5msec)		1000		
Reliability	MTBF			20000		h
	Continuous working time			120		h

6. Coordinate system definition

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-IC24B1-M-D6EC



6.2 Definition of course angle, pitch angle and roll angle

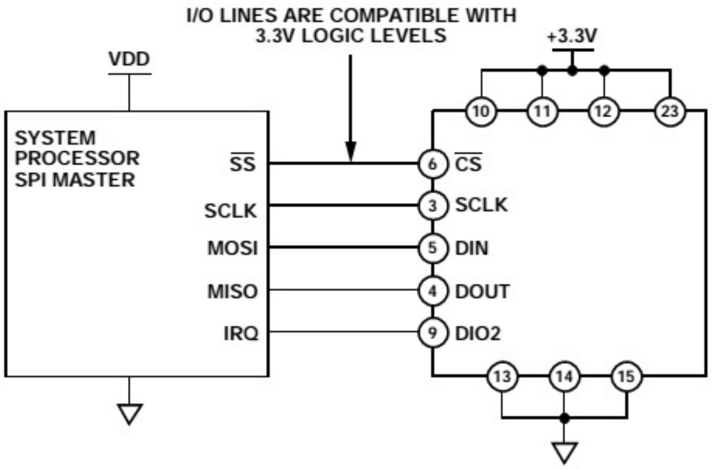
Definition of course angle: Z axis is taken as the rotation axis, anticlockwise is positive, north is zero, and the range is [-180º, 180º];

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

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

7. Read and write data

The BS-IC24B1-M-D6EC is an autonomous sensor system that starts automatically when a valid power source is present. After the initialization process is complete, it begins sampling, processing, and loading the calibrated sensor data into the output registers, which is accessible through the SPI port. The SPI port is typically connected to a compatible port on an embedded processor, see Figure 1 for a connection diagram. Four SPI signals support synchronous serial data transfer. In the factory default configuration, the DIO2 pin provides the data ready signal. This pin goes high when new data is available in the output data register.



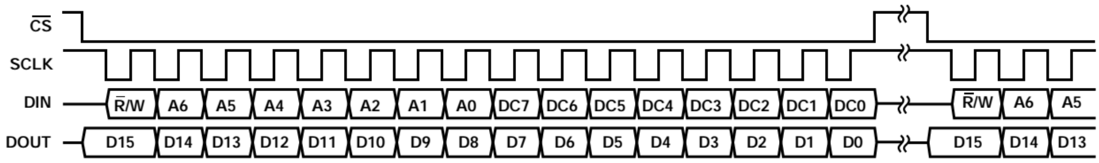
Schematic diagram of connection with external equipment

7.1 Generic Host Processor SPI Settings

Processor settings	**Explain**
Host	The BS-IC24B1-M-D6EC is used as a slave
SCLK ≤ 15 MHz	Maximum serial clock ratio
SPI Mode 3	CPOL = 1 (polar), CPHA = 1 (phase)
MSB first mode	Bit Order
16-bit mode	Shift register/data length

7.2 SPI communication

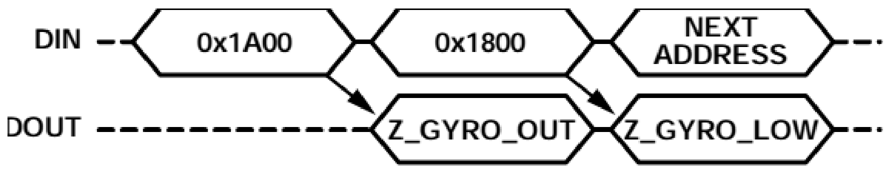
If the previous command is a read request, the SPI port supports full-duplex communication, and the external processor can write DIN while reading DOUT, as shown in the following figure.



SPI Read and Write Timing

Read the sensor data

The BS-IC24B1-M-D6EC automatically starts and activates Page 0 for data register access. After accessing any other page, write 0x00 to the PAGE _ ID register (DIN = 0x8000) to activate Page 0 in preparation for subsequent data accesses. A single register read requires two 16-bit SPI cycles. In the first cycle, a read of the contents of a register is requested using the bit assignment function of fig. 1; In the second cycle, the register contents are output on DOUT. The first bit of the DIN command is 0, followed by the high or low address of the register. The last eight bits are don't care, but the SPI requires the full 16 SCLKs to receive the request. The following figure shows two consecutive register reads, one with DIN = 0x1A00 requesting the contents of the Z _ GYRO _ OUT register, and the other with DIN = 0x1800 requesting the contents of the Z _ GYRO _ LOW register.



SPI Read Example

User Register Memory Map (N/A = Not Applicable)

R/W	PAGE_ID	Address	Default	Register description
R/W	0x00	0x00	0x00	Page identification
R	0x00	0x0E	N/A	Temperature
R	0x00	0x10	N/A	X-axis gyroscope output, low word
R	0x00	0x12	N/A	X-axis gyroscope output, high word
R	0x00	0x14	N/A	Y-axis gyroscope output, low word
R	0x00	0x16	N/A	Y-axis gyroscope output, high word
R	0x00	0x18	N/A	Z-axis gyroscope output, low word
R	0x00	0x1A	N/A	Z-axis gyroscope output, high word
R	0x00	0x1C	N/A	X-axis accelerometer output, low word
R	0x00	0x1E	N/A	X-axis accelerometer output, high word
R	0x00	0x20	N/A	Y-axis accelerometer output, low word
R	0x00	0x22	N/A	Y-axis accelerometer output, high word
R	0x00	0x24	N/A	Z-axis accelerometer output, low word
R	0x00	0x26	N/A	Z-axis accelerometer output, high word
R	0x00	0x28	N/A	X-axis magnetic, high word
R	0x00	0x2A	N/A	Y-axis magnetic, high word
R	0x00	0x2C	N/A	Z-axis magnetic, high-order word
R	0x00	0x2E	N/A	Air pressure output, low word
R	0x00	0x30	N/A	Air pressure output, high word
R/W	0x03	0x00	0x00	Page identification
R/W	0x03	0x06	0x000D	Control, I/O pins, function definition
R/W	0x03	0x08	0x00X0	Control, I/O pins, general purpose
R/W	0x04	0x00	0x00	Page identification
R	0x04	0x20	None	Serial number

Transformation formula

Current temperature = 25 + TEMP _ OUT * 0. 00565

X Gyro example	X_GYRO_OUT	X_GYRO_LOW
	1LSB=0.02°/S	The MSB has a weight of 0.01 °/S, and subsequent bits have half the weight of the previous bit
	0.02*X_GYRO_OUT	0.01*MSB+0.005*.......

The YZ gyro is calculated in a similar manner to the X-axis gyro.

X-axis addition example	X_ACCL_OUT	X_ACCL_LOW
	1LSB=0.8mg	The MSB has a weight of 0.4mg, and subsequent bits have half the weight of the previous bit
	0.8*X_ACCL_OUT	0.4*MSB+0.2*.......

YZ addition is calculated in a similar manner to the X-axis addition.

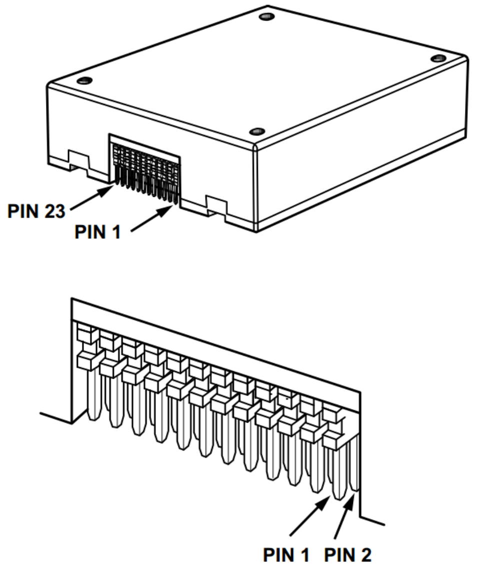
X-axis magnetometer	X_MAGN_OUT
	1LSB=0.1mGauss
	0.1*X_MAGN_OUT

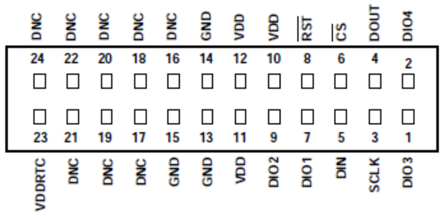
The YZ addition calculation is similar to that of the X-axis magnetometer.

Example of air pressure calculation	BAROM_OUT	BAROM_LOW
	1LSB=40ubar	The MSB has a weight of 20ubar, and subsequent bits have half the weight of the previous bit
	40*BAROM_OUT	20*MSB+10*.......

Note: For the high 16bit and low 16bit of the gyroscope, the adder and the magnetic separator, the final results of the addition are calculated respectively.

8. Electrical interface

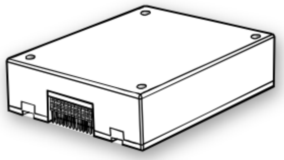


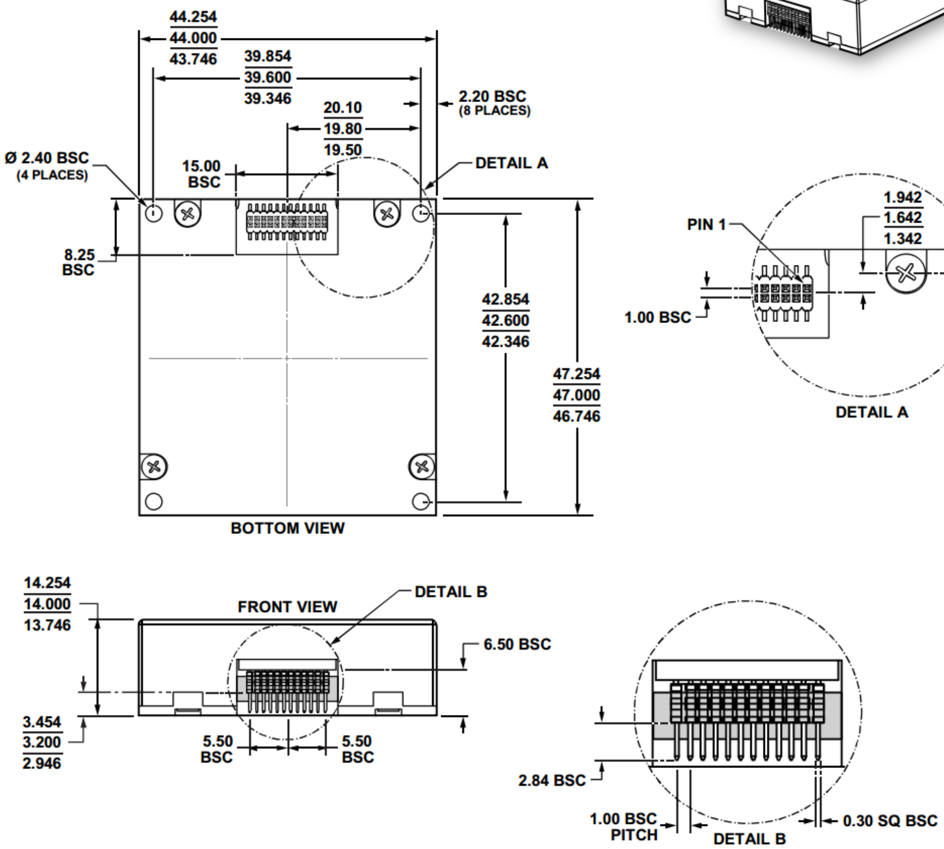


8.1 Structural Installation

Pin sequence number	Name	Type	Description
10，11，12	VDD	Power source	
13，14，15	GND	Power ground	
7	DIO1	Input/output	General purpose IO, configurable
9	DIO2	Input/output	
1	DIO3	Input/output	
2	DIO4	Input/output	
3	SPI-CLK	Input	SPI master-slave mode is configurable, and the default is slave mode.
4	SPI-MISO	Output	
5	SPI-MOSI	Input	
6	SPI-CS	Input	
19	UART-0-TXD	Output	UART0, the baud rate is configurable, and the default is 230400 bps
21	UART-0-RXD	Input	
8	RST	Input	Reset
23	VDDRTC	Power source	Not yet
16~19,21,24	NC	Spare	Retained by the manufacturer

9. Mechanical structure:





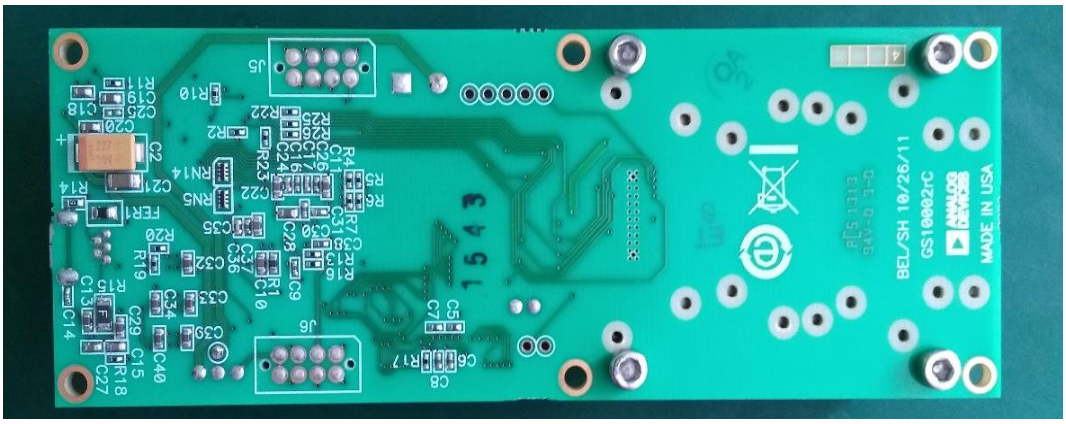
10. Instructions for using the evaluation board

Fully matched to Analog Devices EVAL-ADIS evaluation board

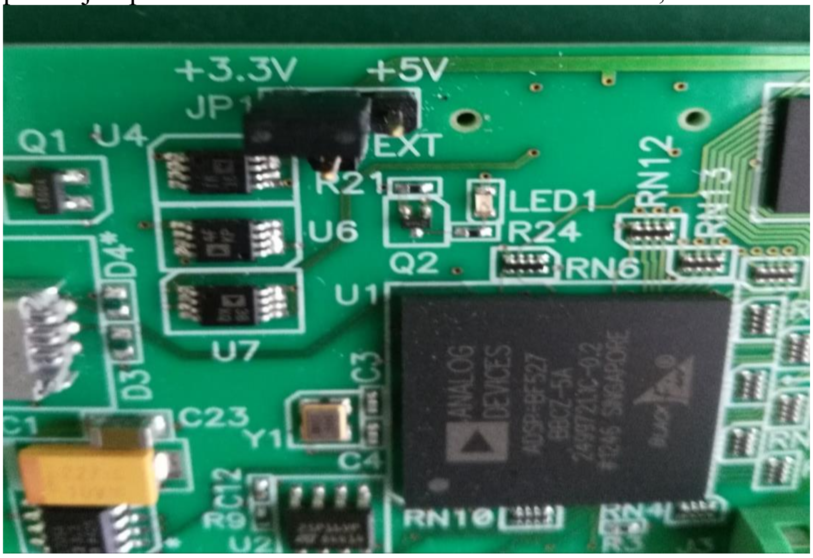
The evaluation board is capable of acquiring raw data from the BS-IC24B1-M-D6EC and supports operating systems such as Win10 and Win7. See the EVAL-ADIS User Guides. PDF for details. The main operation steps are as follows:

1) Install the evaluation board driver, SDPDrivers _ 2.exe.

2) Install the BS-IC24B1-M-D6EC on the evaluation board.

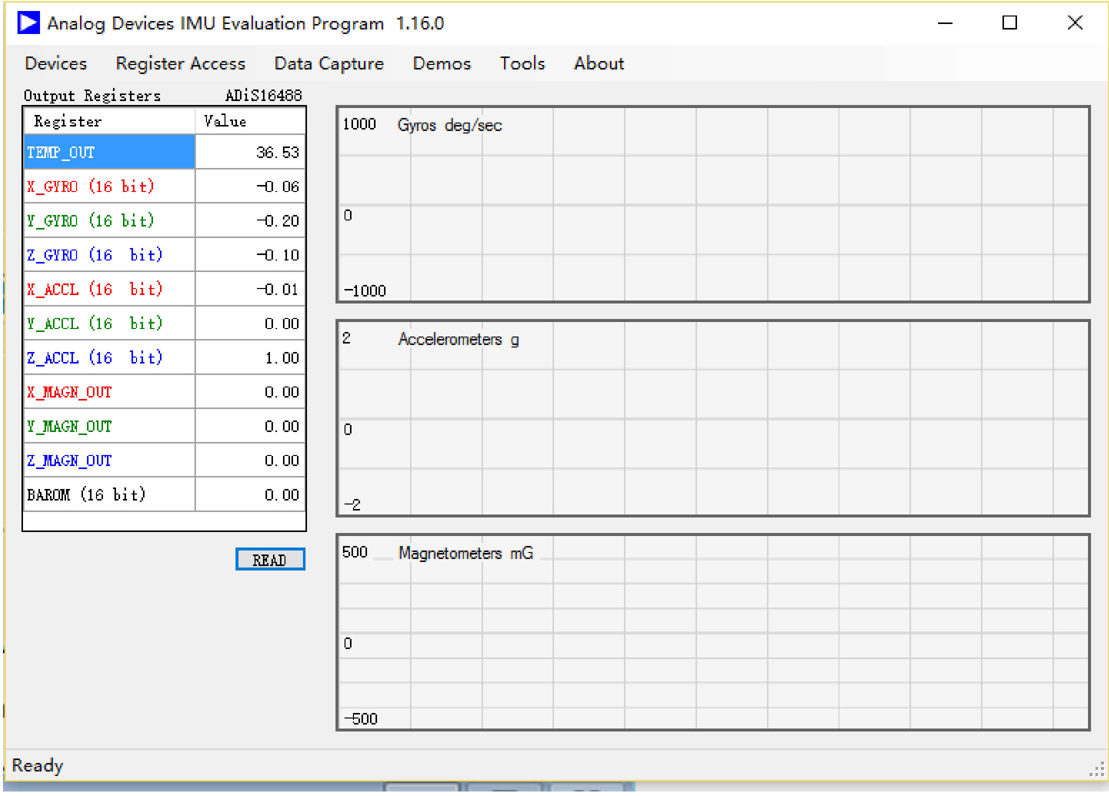


3) The power jumper selection on the evaluation board is 3.3 V;

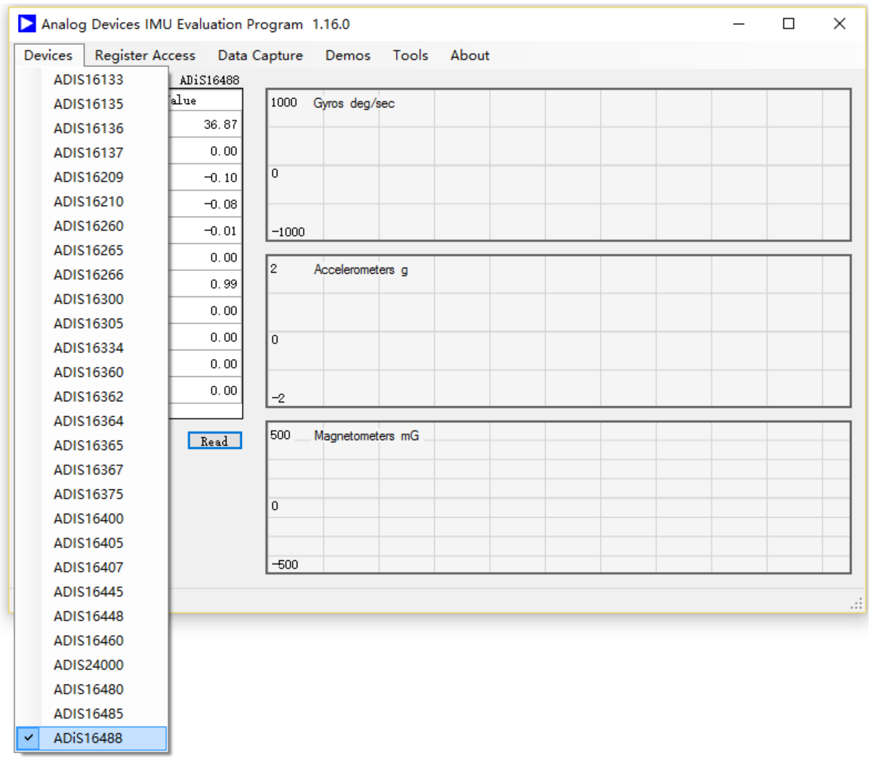


4) Connect the evaluation board and the PC with USB. If LED2 lights up first, it indicates that the power supply of the evaluation board is normal. After about 5 to 10 seconds, LED1 lights up, it indicates that the USB port of the evaluation board is successfully connected to the PC.

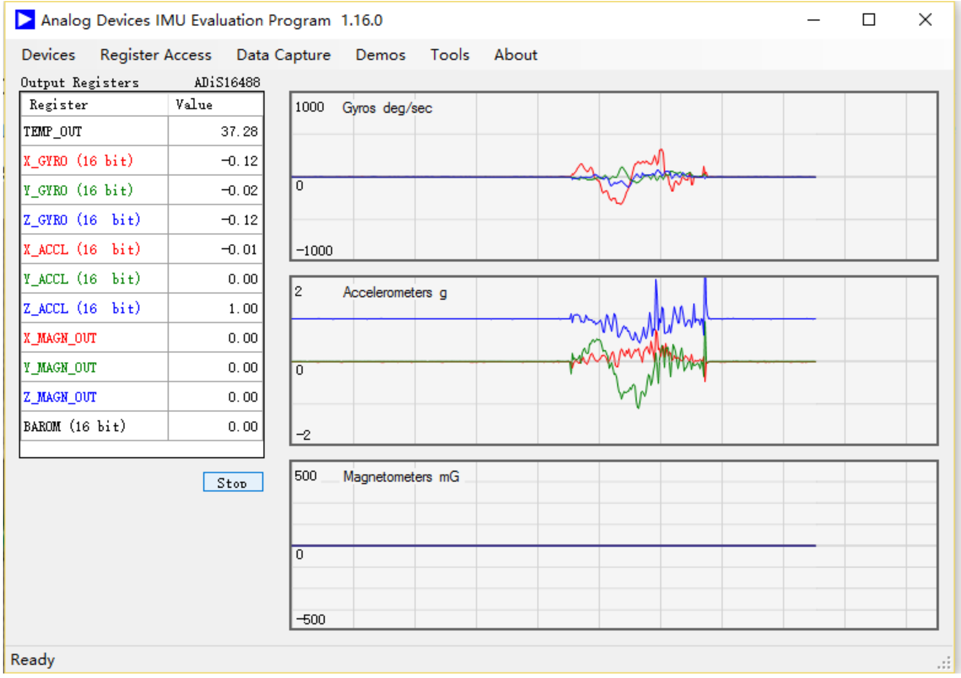
5) Open the evaluation board test software IMU _ Evaluation. Exe.



6) Select ADIS16488B-1 in Devices;



7) Click Read to read the data and display it on the interface.



11. Selection guidance

1) BS-IC24B1-M-D6EC: Inertial Measurement Unit;

The differences between the different types are shown in the following table:

Code name	Name	Heading	Pitch, roll	Speed	Location	Acceleration	Angular velocity
BS-IC24B1-M-D6EC	Inertial Measurement Unit	×	√	×	×	√	√