WitMotion Shenzhen Co., Ltd| **Datasheet**

AHRS IMU Sensor | WTGAHRS1

The Robust Acceleration, Angular velocity, Angle, Magnetic filed & Air Pressure & GPS Monitor Detector

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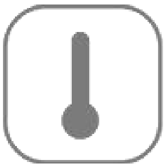
The WTGAHRS1 is a IMU sensor device, detecting acceleration, angular velocity, angle , magnetic filed , air pressure as well as GPS data. The robust housing and the small outline makes it perfectly suitable for industrial applications such as condition monitoring and predictive maintenance. Configuring the device enables the customer to address a broad variety of application by interpreting the sensor data by smart algorithms and Kalman filtering.

BUILT-IN SENSORS

Accelerometer

Gyroscope

Magnetometer



Barometer

GPS Module

Tutorial Link

Google Drive

Link to instructions DEMO:
WITMOTION Youtube Channel
WTGAHRS1 Playlist

If you have technical problems or cannot find the information that you need in the provided documents, please contact our support team. Our engineering team is committed to providing the required support necessary to ensure that you are successful with the operation of our AHRS sensors.

Contact

Technical Support Contact Info

Application

- AGV Truck
- Platform Stability
- Auto Safety System
- 3D Virtual Reality
- Industrial Control
- Robot
- Car Navigation
- UAV
- Truck-mounted Satellite Antenna Equipment

Contents

1 Overview

WTGAHRS1's scientific name is AHRS IMU sensor. A sensor measures 3-axis angle, angular velocity, acceleration, magnetic field, air pressure and GPS data. Its strength lies in the algorithm which can calculate three-axis angle accurately.

WTGAHRS1 is employed where the highest measurement accuracy is required. WTGAHRS1 offers several advantages over competing sensor:

• Heated for best data availability: new WITMOTION patented zero-bias automatic detection calibration algorithm outperforms traditional accelerometer sensor

• High precision Roll Pitch Yaw (X Y Z axis) Acceleration + Angular Velocity + Angle + Magnetic Field + Air Pressure + GPS data output

• Low cost of ownership: remote diagnostics and lifetime technical support by WITMOTION service team

• Developed tutorial: providing manual, datasheet, Demo video, PC software, mobile phone APP, and 51 serial, STM32, Arduino, and Matlab sample code, communication protocol

• WITMOTION sensors have been praised by thousands of engineers as a recommended attitude measurement solution

2 Features

- Built-in WT901B + GPS + BeiDou module, for detailed parameters, please refer to the instructions of WT901B.
- The default baud rate of this device is 9600 and could be changed.
- The interface of this product only leads to a serial port
- The module consists of a high precision gyroscope, accelerometer, geomagnetic field and barometer sensor. The product can solve the current real-time motion posture of the module quickly by using the high-performance microprocessor, advanced dynamic solutions and Kalman filter algorithm.
- The advanced digital filtering technology of this product can effectively reduce the measurement noise and improve the measurement accuracy.
- Maximum 200Hz data output rate. Output content can be arbitrarily selected, the output speed 0.2HZ~ 200HZ adjustable.

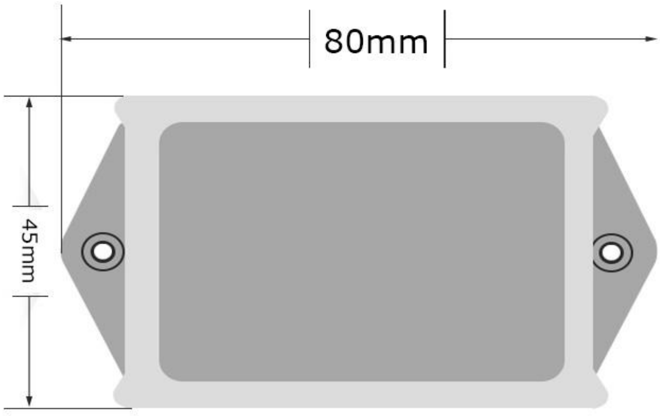
3 Specification

3.1 Parameter

Parameter	Specification
➢ Working Voltage	TTL:3.3V-5V
➢ Current	<40mA
➢ Size	61.2mm x 45.2mm X 27.8mm
➢ Data	Angle: X Y Z, 3-axis Acceleration: X Y Z, 3-axis Angular Velocity: X Y Z, 3-axis Magnetic Field : X Y Z, 3-axis Air Pressure : 1-Axis Positioning (longitude, latitude) Ground speed Number of satellites Time, Quaternion
➢ Output frequency	0.2Hz--200Hz
➢ Interface	Serial TTL level,
➢ Baud rate	9600(default, could be changed)

Measurement Range & Accuracy		
Sensor	Measurement Range	Accuracy/ Remark
➢ Acceleromet	X, Y, Z, 3-axis ±16g	Accuracy: 0.01g Resolution: 16bit Stability: 0.005g
➢ Gyroscope	X, Y, Z, 3-axis -±2000°/s	Resolution: 16bit Stability: 0.05°/s
➢ Magnetometer	X, Y, Z, 3-axis ±4900μT	0.15μT/LSB typ. (16-bit) AK8963 Magnetometer Chip
➢ Angle/ Inclinometer	X, Y, Z, 3-axis X, Z-axis: ±180° Y ±90° (Y-axis 90° is singular point)	Accuracy:X, Y-axis: 0.05° Z-axis: 1° (after magnetic calibration)
➢ Barometer	1-axis	Accuracy : 1m
➢ GPS Module	Altitude :50000m Speed Velocity:50000m/s	Position Accuracy:2.5m Direction Accuracy :0.5°

3.2 Size



Parameter	Specification	Tolerance	Comment
Length	80	±0.1	Unit: millimeter.
Width	45	±0.1	
Height	28	±0.1	
Weight	50	±1	Unit: gram

3.3 Axial Direction

The coordinate system used for attitude angle settlement is the northeast sky coordinate system. Place the module in the positive direction, as shown in the figure below, direction right is the X-axis, the direction forward is the Y-axis, and direction upward is the Z-axis. Euler angle represents the rotation order of the coordinate system when the attitude is defined as Z-Y-X, that is, first turn around the Z-axis, then turn around the Y-axis, and then turn around the X-axis.

4 PIN Definition

PIN	Color	Function
➢ VCC	RED	Input Supply TTL :powered by 3.3-5V
➢ RX	GREEN	Serial data input RX connected with TX
➢ TX	YELLOW	Serial data output TX connected with RX
➢ GND	BLACK	Ground GND

5 Communication Protocol

Level: TTL level

Baud rate:4800, 9600 (default), 19200 38400, 57600, 115200, 230400, 460800, 921600, stop bit and parity

5.1 Output Data Format

5.1.1 Time Output

0x55	0x50	YY	MM	DD	hh	mm	ss	msL	msH	SUM

YY：Year, 20YY Year

MM：Month

DD：Day

hh：hour

mm：minute

ss：Second

ms：Millisecond

Millisecond calculate formula：

ms=((msH<<8)|msL)

Sum=0x55+0x51+YY+MM+DD+hh+mm+ss+ms+TL

5.1.2 Acceleration Output

0x55	0x51	AxL	AxH	AyL	AyH	AzL	AzH	TL	TH	SUM

Calculate formula：

a_x=((AxH<<8)|AxL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

a_y=((AyH<<8)|AyL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

a_z=((AzH<<8)|AzL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

Temperature calculated formular：

T=((TH<<8)|TL)/100 ℃

Checksum：

Sum=0x55+0x51+AxH+AxL+AyH+AyL+AzH+AzL+TH+TL

Note：

1. The data is sent in hexadecimal, not ASCII code.

Each data is transmitted in turn of low byte and high byte, and the two are combined into a signed short type data.

For example, X-axis acceleration data Ax, where AxL is low byte and AxH is high byte. The conversion method is as follows:

Assuming that Data is actual data, DataH is its high byte, and DataL is its low byte, then: Data = (short) (DataH << 8 | DataL).

It must be noted that DataH needs to be coerced into a signed short data and then shifted, and the data type of Data is also a signed short type, so that it can represent negative numbers.

5.1.3 Angular Velocity Output

0x55	0x52	wxL	wxH	wyL	wyH	wzL	wzH	TL	TH	SUM

Calculated formular：

w_x=((wxH<<8)|wxL)/32768*2000(°/s)

w_y=((wyH<<8)|wyL)/32768*2000(°/s)

w_z=((wzH<<8)|wzL)/32768*2000(°/s)

Temperature calculated formular：

T=((TH<<8)|TL) /100 ℃

Checksum：

Sum=0x55+0x52+wxH+wxL+wyH+wyL+wzH+wzL+TH+TL

5.1.4 Angle Output

0x55	0x53	RollL	RollH	PitchL	PitchH	YawL	YawH	VL	VH	SUM

Calculated formular:
Roll(X axis)Roll=((RollH<<8)|RollL)/32768*180(°)
Pitch(Y axis)Pitch=((PitchH<<8)|PitchL)/32768*180(°)
Yaw(Z axis)Yaw=((YawH<<8)|YawL)/32768*180(°)
Version calculated formula:
Version=(VH<<8)|VL
Checksum:
Sum=0x55+0x53+RollH+RollL+PitchH+PitchL+YawH+YawL+VH+VL
Note:

1. The coordinate system used for attitude angle settlement is the northeast sky coordinate system. Place the module in the positive direction, as the figure shown in Chapter 3.3, direction right is the X-axis, the direction forward is the Y-axis, and direction upward is the Z-axis. Euler angle represents the rotation order of the coordinate system when the attitude is defined as Z-Y-X, that is, first turn around the Z-axis, then turn around the Y-axis, and then turn around the X-axis.

2. Although the range of the roll angle is ± 180 degrees, in fact, since the coordinate rotation sequence is Z-Y-X, when expressing the attitude, the range of the pitch angle (Y-axis) is only ± 90 degrees, and it will change to less than 90 after exceeding 90 degrees Degrees while making the X-axis angle greater than 180 degrees. For detailed principles, please Google Euler angle and posture-related information.

3. Since the three axes are coupled, they will show independent changes only at small angles, and the attitude angles will change at large angles. For example, when the Y-axis is close to 90 degrees, even if the attitude only rotates around the Y-axis, the angle of the axis will also change greatly, which is an inherent problem with Euler angles indicating attitude.

5.1.5 Magnetic Output

0x55	0x54	HxL	HxH	HyL	HyH	HzL	HzH	TL	TH	SUM

Calculated formular:
Magnetic(x axis)Hx=((HxH<<8)| HxL)
Magnetic(y axis)Hy=((HyH <<8)| HyL)
Magnetic(z axis)Hz =((HzH<<8)| HzL)
Temperature calculated formular:
T=((TH<<8)|TL) /100℃

Checksum:
Sum=0x55+0x53+HxH+HxL+HyH+HyL+HzH+HzL+TH+TL

5.1.6 Atmospheric Pressure and Height Output

0x55	0x56	P0	P1	P2	P3	H0	H1	H2	H3	SUM

Calculated formular:
Atmospheric pressure P = ((P3<<24)| (P2<<16)| (P1<<8)| P0 (Pa)
Height H = ((H3<<24)| (H2<<16)| (H1<<8)| H0(cm)

Checksum:
Sum=0x55+0x54+P0+P1+P2+P3+H0+H1+H2+H3

5.1.7 Longitude and Latitude Output

0x55	0x57	Lon0	Lon 1	Lon 2	Lon 3	Lat0	Lat 1	Lat 2	Lat 3	SUM

Calculated formular：

Longitude Lon = ((Lon 3<<24)| (Lon 2<<16)| (Lon 1<<8)| Lon 0

In NMEA0183 standard , GPS output format is ddmm.mmmmm (dd for the degree, mm.mmmmm is after decimal point), the module removes the decimal point during output, so the degree of longitude can be calculated as follows:

dd=Lon/100000000;

mm.mmmmm=(Lon%10000000)/100000；(% calculate Remainder)

Latitude Lat = ((Lat 3<<24)| (Lat 2<<16)| (Lat 1<<8)| Lat 0 (cm)

In NMEA0183 standard , GPS output format is ddmm.mmmmm (dd for the degree, mm.mmmmm is after the decimal point), the module removes the decimal point during output, so the degree of latitude can be calculated as follows::

dd=Lat/100000000;

mm.mmmmm=(Lat%10000000)/100000;(% calculate Remainder)

Checksum:

Sum=0x55+0x54+ Lon 0+ Lon 1+ Lon 2+ Lon 3+ Lat 0+ Lat 1+ Lat 2+ Lat 3

Note: This only applies to devices with GPS module(WTGAHRS1, WTGAHRS2)

5.1.8 Ground Speed Output

0x55	0x58	GPSHeightL	GPSHeightH	GPSYawL	GPSYawH
GPSV0	GPSV 1	GPSV 2	GPSV 3	SUM	

Calculated formular：

GPSHeight = ((GPSHeightH<<8)| GPSHeightL)/10 (m)

GPSYaw =((GPSYawH <<8)| GPSYawL)/10 (°)

GPSV = (((GPSV 3<<24)| (GPSV 2<<16)| (GPSV 2<<8)|GPSV0)/1000(km/h)

Checksum：

Sum=0x55+0x54+ GPSHeightL + GPSHeightH + GPSYawL + GPSYawH + GPSV0+ GPSV 1+ GPSV 2+ GPSV 3

5.1.9 Quaternion

0x55	0x59	Q0L	Q0H	Q1L	Q1H	Q2L	Q2H	Q3L	Q3H	SUM

Calculated formular：

Q0=((Q0H<<8)|Q0L)/32768

Q1=((Q1H<<8)|Q1L)/32768

Q2=((Q2H<<8)|Q2L)/32768

Q3=((Q3H<<8)|Q3L)/32768

Checksum：

Sum=0x55+0x59+Q0L+Q0H+Q1L +Q1H +Q2L+Q2H+Q3L+Q3H

5.1.10 Satellite Positioning Accuracy Output

0x55	0x5A	SNL	SNH	PDOPL	PDOPH	HDOPL	HDOPH	VDOPL	VDOPH	SUM

Calculated formula：

Satellite quantity:SN=((SNH<<8)|SNL)

Location positioning accuracy：PDOP=((PDOPH<<8)|PDOPL)/32768

Horizontal positioning accuracy：HDOP=((HDOPH<<8)| HDOPL)/32768

Vertical positioning accuracy：VDOP=((VDOPH<<8)| VDOPL)/32768

Checksum:

Sum=0x55+0x59+ SNL + SNH + PDOPL + PDOPH + HDOPL + HDOPH + VDOPL + VDOPH

5.2 Config Commands

Reminder:

1. Data format

0xFF	0xAA	Address	DataL	DataH

5.2.1 Register Address

Address	Symbol	Meaning
0x00	SAVE	Save
0x01	CALSW	Calibration
0x02	RSW	Return data content
0x03	RATE	Return data Speed
0x04	BAUD	Baud rate
0x05	AXOFFSET	X axis Acceleration bias
0x06	AYOFFSET	Y axis Acceleration bias
0x07	AZOFFSET	Z axis Acceleration bias
0x08	GXOFFSET	X axis angular velocity bias
0x09	GYOFFSET	Y axis angular velocity bias
0x0a	GZOFFSET	Z axis angular velocity bias
0x0b	HXOFFSET	X axis Magnetic bias
0x0c	HYOFFSET	Y axis Magnetic bias
0x0d	HZOFFSET	Z axis Magnetic bias
0x0e~0x19	RSV	Reserved
0x1a	IICADDR	IIC address
0x1b	LEDOFF	Turn off LED
0x1c	GPSBAUD	GPS baud rate
0x30	MMYY	Month , Year
0x31	HHDD	Hour , Day
0x32	SSMM	Second , Minute
0x33	MS	Millisecond
0x34	AX	X axis Acceleration
0x35	AY	Y axis Acceleration
0x36	AZ	Z axis Acceleration
0x37	GX	X axis angular velocity
0x38	GY	Y axis angular velocity
0x39	GZ	Z axis angular velocity
0x3a	HX	X axis Magnetic

0x3b	HY	Y axis Magnetic
0x3c	HZ	Z axis Magnetic
0x3d	Roll	X axis Angle
0x3e	Pitch	Y axis Angle
0x3f	Yaw	Z axis Angle
0x40	TEMP	Temperature
0x41~0x44	RSV	D0Status
0x45	PressureL	Pressure Low Byte
0x46	PressureH	Pressure High Byte
0x47	HeightL	Height Low Byte
0x48	HeightH	Height High Byte
0x49	LonL	Longitude Low Byte
0x4a	LonH	Longitude High Byte
0x4b	LatL	Latitude Low Byte
0x4c	LatH	Latitude High Byte
0x4d	GPSHeight	GPS Height
0x4e	GPSYaw	GPS Yaw
0x4f	GPSVL	GPS speed Low byte
0x50	GPSVH	GPS speed High byte
0x51	Q0	Quaternion Q0
0x52	Q1	Quaternion Q1
0x53	Q2	Quaternion Q2
0x54	Q3	Quaternion Q3

5.2.2 Save Configuration

0xFF	0xAA	0x00	SAVE	0x00

SAVE：Save

0：Save current configuration

1：set to default setting

5.2.3 Calibrate

0xFF	0xAA	0x01	CALSW	0x00

CALSW：Set calibration mode

0：Exit calibration mode

1：Enter Gyroscope and Accelerometer calibration mode

2：Enter magnetic calibration mode

3：Set height to 0

5.2.4 Installation Direction

0xFF	0xAA	0x23	DIRECTION	0x00

DIRECTION：set installation direction

0：set to horizontal installation

1：set to vertical installation

5.2.5 Sleep/ Wake up

0xFF	0xAA	0x22	0x01	0x00

After sending the command, the module enters the sleep (standby) state, and once again, the module enters the working state from the standby state.

Eg:

1. FF AA 69 88 B5(Unlock)
2. FF AA 22 01 00 (Sleep State)
3. FF AA 22 01 00 (Unsleep State)

5.2.6 Algorithm Transition

0xFF	0xAA	0x24	ALG	0x00

ALG：6-axis/ 9-axis algorithm transition

0：switch to 9-axis algorithm

1：switch to 6-axis algorithm

5.2.7 Gyroscope Automatic Calibration

0xFF	0xAA	0x63	GYRO	0x00

GYRO：gyroscope automatic calibration

0：set to gyroscope automatic calibration

1：removed to gyroscope automatic calibration

5.2.8 Return Content

0xFF	0xAA	0x02	RSWL	RSWH

RSWL byte definition

byte	7	6	5	4	3	2	1	0
Name	0x57 pack	0x56 pack	0x55 pack	0x54 pack	0x53 pack	0x52 pack	0x51 pack	0x50 pack
default	0	0	0	1	1	1	1	0

RSWH byte definition

byte	7	6	5	4	3	2	1	0
Name	X	X	X	X	X	0x5A pack	0x59 pack	0x58 pack
default	0	0	0	0	0	0	0	0

X is an undefined value.

0x50 pack：time pack

0：Not output 0X50 pack

1：Output 0X50 pack

0x51 pack：Acceleration pack

0：Not output 0x51 pack

1：Output 0x51 pack

0x52 pack：Angular velocity pack

0：Not output 0x52 packet

1：Output 0x52 pack

0x53 pack：Angle Pack

0：Not output 0x53 pack

1：Output 0x53 pack

0x54 pack：Magnetic Pack

0：Not output 0x54 pack

1：Output 0x54 pack

0x55 pack：Port status pack

0：Not output 0x55 pack

1：Output 0x55 pack

0x56 pack：Atmospheric pressure &Height Pack

0：Not output 0x56 pack

1：Output 0x56 pack

0x57 pack：Longitude and Latitude Output Pack

0：Not output 0x57 pack

1：Output 0x57 pack

0x58 pack：GPS speed Pack

0：Not output 0x58 pack

1：Output 0x58 pack

0x59 pack：Quaternion Pack

0：Not output 0x59 pack

1：Output 0x59 pack

0x5A pack：Satellite position accuracy

0：Not output 0x5A pack

1：Output 0x5A pack

5.2.9 Return Rate

0xFF	0xAA	0x03	RATE	0x00

RATE：return rate

0x01 :0.2Hz
0x02：0.5Hz
0x03：1Hz
0x04：2Hz
0x05：5Hz
0x06：10Hz(default)
0x07：20Hz
0x08：50Hz
0x09：100Hz
0x0a：125Hz
0x0b：200Hz
0x0c：Single
0x0d: Not output

After the setup is complete, need to click save, and re-power the module to take effect.

Eg(20Hz of Return Rate):
1. FF AA 69 88 B5(Unlock)
2. FF AA 03 07 00(20HZ)
3.FF AA 00 00 00(Save Config)

5.2.10 Baud Rate

0xFF	0xAA	0x04	BAUD	0x00

BAUD：

0x01：4800

0x02：9600(default)

0x03：19200

0x04：38400

0x05：57600

0x06：115200

0x07：230400

0x08：460800

0x09：921600

5.2.11 Set X Axis Acceleration Bias

0xFF	0xAA	0x05	AXOFFSETL	AXOFFSETH

AXOFFSETL：X axis Acceleration bias low byte

AXOFFSETH：X axis Acceleration bias high byte

AXOFFSET= (AXOFFSETH <<8) | AXOFFSETL

Note：After setting the acceleration bias, the output value of the acceleration is the sensor measured value minus the bias value.

5.2.12 Set Y Axis Acceleration Bias

0xFF	0xAA	0x06	AYOFFSETL	AYOFFSETH

AYOFFSETL：Y axis Acceleration bias low byte

AYOFFSETH：Y axis Acceleration bias high byte

AYOFFSET= (AYOFFSETH <<8) | AYOFFSETL

Note：After setting the acceleration bias, the output value of the acceleration is the sensor measured value minus the bias value.

5.2.13 Set Z Axis Acceleration Bias

0xFF	0xAA	0x07	AZOFFSETL	AZOFFSETH

AZOFFSETL：Z axis Acceleration bias low byte
AZOFFSETH：Z axis Acceleration bias high byte
AZOFFSET= (AZOFFSETH <<8) | AZOFFSETL
Note：After setting the acceleration bias, the output value of the acceleration is the sensor measured value minus the bias value.

5.2.14 Set X Axis Angular Velocity Bias

0xFF	0xAA	0x08	GXOFFSETL	GXOFFSETH

GXOFFSETL：Set X axis Angular velocity bias low byte
GXOFFSETH：Set Y axis Angular velocity bias high byte
GXOFFSET= (GXOFFSETH <<8) | GXOFFSETL
Note：After setting the angular velocity zero deviation, the output value of the angular velocity is the sensor measurement value minus the zero deviation value.

5.2.15 Set Y Axis Angular Velocity Bias

0xFF	0xAA	0x09	GYOFFSETL	GYOFFSETH

GYOFFSETL：Set X axis Angular velocity bias low byte
GYOFFSETH：Set X axis Angular velocity bias high byte
GYOFFSET= (GYOFFSETH <<8) | GYOFFSETL
Note：After setting the angular velocity zero deviation, the output value of the angular velocity is the sensor measurement value minus the zero deviation value.

5.2.16 Set Z Axis Angular Velocity Bias

0xFF	0xAA	0x0a	GXOFFSETL	GXOFFSETH

GZOFFSETL：Set Z axis Angular velocity bias low byte
GZOFFSETH：Set Z axis Angular velocity bias low byte
GZOFFSET= (GZOFFSETH <<8) | GZOFFSETL

Note：After setting the angular velocity zero deviation, the output value of the angular velocity is the sensor measurement value minus the zero deviation value.

5.2.17 Set X Axis Magnetic Bias

0xFF	0xAA	0x0b	HXOFFSETL	HXOFFSETH

HXOFFSETL：Set X axis magnetic bias low byte
HXOFFSETH：Set X axis magnetic bias high byte
HXOFFSET= (HXOFFSETH <<8) | HXOFFSETL

Note：After setting the magnetic field bias, the output value of the magnetic field is the sensor measured value minus the zero bias value.

5.2.18 Set Y Axis Magnetic Bias

0xFF	0xAA	0x0c	HXOFFSETL	HXOFFSETH

HXOFFSETL：Set Y axis magnetic bias low byte
HXOFFSETH：Set Y axis magnetic bias high byte
HXOFFSET= (HXOFFSETH <<8) | HXOFFSETL

Note：After setting the magnetic field bias, the output value of the magnetic field is the sensor measured value minus the zero bias value.

5.2.19 Set Z Axis Magnetic Bias

0xFF	0xAA	0x0d	HXOFFSETL	HXOFFSETH

HXOFFSETL：Set Y axis magnetic bias low byte
HXOFFSETH：Set Z axis magnetic bias high byte
HXOFFSET= (HXOFFSETH <<8) | HXOFFSETL

Note：After setting the magnetic field bias, the output value of the magnetic field is the sensor measured value minus the zero bias value.

5.2.20 Set GPS baud

0xFF	0xAA	0x1c	GPSBAUD	0x00

GPSBAUD：
Baud: Time information pack
0x00：2400
0x01：4800
0x02：9600（default）
0x03：19200
0x04：38400
0x05：57600
0x06：115200
0x07：230400
0x08：460800
0x09：921600

After set it up, you need to save the configuration button, Click "Save Config"button and then restart the module.